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THE SCALLOP OBSERVER PROGRAM AND STATEWIDE DATA ANALYSIS

SUMMARY TO THE BOARD OF FISHERIES

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INTRODUCTION

Initial Implementation of the Scallop Observer Program

In order to address concerns about increasing vessel effort and possible over exploitation of the scallop resource, on May 21, 1993 Commissioner Rosier declared the scallop fishery to be a high impact and emerging fishery. As a result of this action, the Department implemented an observer program to monitor the scallop catch and the crab bycatch of the scallop fleet.

With certain exceptions the coverage was to be universal. It was determined in the established scallop fishery in Cook Inlet, the restriction of a single six foot dredge and log book requirement, coupled with onboard spot checks of bycatch by Department personnel were sufficient reasons to waive the observer requirement. In Yakutat, it was established that due to low crab bycatch numbers, vessels under 65 feet would not be required to have an observer.

Faced with the task of establishing an effective observer program and at the same time causing a minimum of disruption to the fishery, it was decided to use the existing mandatory crab observer program and personnel to implement the observer requirement. The crab observer program is run by private contractors who are responsible for observer training and logistics. The Department is responsible for certifying that the observers are qualified, and also briefing and debriefing of the observers after each fishing trip.

THE SCALLOP OBSERVER PROGRAM

Observer Training

Work began immediately on designing the scallop observer program. The basic data requirements were outlined, forms and an observer manual were developed. An initial scallop observer training session was conducted by the University of Alaska-Anchorage on June 28-29, 1993 at the North Pacific Fisheries Observer Training Center. Twelve observers successfully completed the training program and by July 1, the program was in place. The University of Alaska deserves special recognition for their assistance in making this program happen. By January 1994, three additional training sessions had been held by UAA with 10 more crab observers becoming certified as scallop observers. The Department also trained 2 contract observers. In addition, four Fish and Game personnel were trained as observers to fill in when contractor supplied observers were not available (Table 1).

Observer Program Costs

The scallop observer program resulted in considerable costs to both the Department and the industry. The department spent at least $200,000 on the program, mostly in personnel costs. Since no funds have been allocated to the program, this represents a significant budget shortfall.

For the industry, the cost of paying the contractors for the observers, $225,000[2], is only a part of the cost. Vessels must pay the costs of transporting the observers to and from the vessel, and must also bear the cost of transporting the observers to and from all required briefing and debriefing sites. Lost fishing time and fuel costs must also be considered.

Data Collection Forms

Observers were required to collect a wide range of data. The questions that needed to answered were:

1. What is the bycatch associated with the scallop fleet, especially of commercial species, such as crab and halibut? What damage is done to these species by the dredging operation?

2. Where is the fleet fishing? What are the catch rates?

3. What are the age structure, sexual status, and growth rates of the scallop resource in the various areas of the state?

Forms were developed to gather the data needed to answer these questions (Appendices A-G). The fishing log form was to be filled out by the vessel skipper. It contains the basic time, distance, location, and catch information on each tow completed. The observer haul form is used to record the crab and halibut bycatch. Observers were instructed to record these numbers from 6 tows per day. In addition, this form was used once a day to record the catch composition of all species caught, including non-commercial species. All crab and halibut recorded on the haul form were also entered on the halibut form and the crab size and injury forms. These forms were used to measure each animal and categorize the injuries suffered in the dredge. One hundred scallops per day were measured, aged, and assessed for the stage of gonadal development. This information was recorded on the scallop size frequency form.

Other forms developed included: a radio reporting form, a form for a skipper evaluation of the observer, a briefing/debriefing checklist, and a weekly summary form of catch and bycatch numbers. Observers were also required to collect 50 scallop shells per trip and mark the growth rings on each shell. This would allow the Department to evaluate the accuracy of each observer's aging determinations. Twelve small scallops were requested from each statistical area fished to assist with the placement of first annuli which sometimes becomes obscured in older scallops. Observers were requested to keep detailed personal logs of their activities on board, and were encouraged to take lots of photos of the operation of the vessel and any photos which might be needed as evidence in making a legal case against the vessel.

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[2] This cost represents the average observer cost times the number of observer-days from briefing to debriefing. Some vessels are actually required to pay the observer for travel time so this number underestimates this expense.

STATEWIDE DATA ANALYSIS: 1993 SCALLOP OBSERVER PROGRAM

Observer Coverage and Data Collection

In 1993, not considering vessels with exemptions, 18 different observers were placed on 12 vessels. Nearly 900 days of fishing were observed, not including travel days and weather days. The vessel captains recorded 12,881 hauls on their logs and roughly 1/3 these hauls were sampled by the observers. The resulting pile of data forms was both impressive and oppressive. Two hundred and ten pounds of forms were completed, making a stack of paper nearly 6 feet tall. Over 50,000 scallops and 65,000 Tanner crab were measured. One hundred and fifty-six separate briefings and debriefings were conducted by the Department in 6 locations state-wide. These briefings and debriefings by themselves consumed 150 hours of personnel time.

Fishing Locations

The scallop fleet can be described as mobile and wide ranging. The fleet fished in 86 different statistical areas statewide, covering all the ADF&G administrative regions of the state. Figure 1 shows tow locations in statistical areas where 3 or more vessels fished.

Scallop Shell Heights Statewide

The scallop shell size (height) varied in the various fishing areas across the state (Figures 2-6). Scallop height ranged from 33 to 205 mm, 1.5 to 9.1 inches, with larger scallops being found in the waters off Kodiak Island (average of 142.8 mm, 6.3 inches) and Bering Sea (average of 146.3 mm, 6.5 inches). The other areas (Yakutat, Prince William Sound, Alaska Peninsula and Dutch Harbor), tended to have smaller scallops with averages ranging between 117.7 (Yakutat) to 128.0 mm (Dutch Harbor).

Age Determination in Scallops

Aging scallops can be difficult, since the first year growth ring is not always obvious, and it is sometimes difficult to distinguish between growth rings and growth checks caused by previous dredging or storms. A set of 35 scallop shells from around the state have been sent to a scallop expert in Nanaimo, British Columbia to establish a reference set of shells for training and verification of observer data. The Department is awaiting the results of this study.

Most observers were very conscientious and kept careful records, and their shelling aging on the average can probably be considered to be accurate within 1 or 2 years. The scallops of Yakutat and Prince William Sound were judged to average 6.5 years age, while the scallops off Kodiak and Alaska Peninsula tended to be a little older, about 8 years of age. The scallops of Dutch Harbor and the Bering Sea were quite different from the rest at 5 and 10 years of age respectively (Table 2).

Statewide Scallop Catch and Effort

Total scallop dredging effort by the observed fleet in the post-June 30 1993 fishery (Figure 7) was 11 thousand tow-hours, with the highest effort for any single management area occurring in Kodiak (Area K) at 5,234 tow-hours. Effort in the Bering Sea (Area Q) was also high at 2,914 tow-hours. Excluding the Southeastern (Area A) fishery for reasons of confidentiality of data, effort for the remaining areas ranged from 320 tow-hours for the Prince William Sound (Area E) fishery to 1,017 tow-hours for the Yakutat (Area D) fishery.

Retained scallop weight recorded on the skipper's logs in the observer database is round weight (as opposed to meat weight). Round weight pounds of retained scallops in the post-June 30 observed 1993 fishery (Figure 8) totaled roughly 11.6 million pounds. The greatest catches of scallops occurred in the Kodiak (Area K), Bering Sea (Area Q), and Yakutat (Area D) fisheries at approximately 3.6, 3.4, and 2.1 round weight million pounds of retained scallops, respectively. Excluding the Southeastern (Area A) fishery, round weight pounds of retained scallops in the remaining areas ranged from roughly 0.4 million pounds for the Dutch Harbor (Area O) fishery to 1.0 million pounds for the Alaska Peninsula (Area M) fishery.

Scallop CPUE (round weight pounds of retained scallops per tow-hour) for the post-June 30 observed 1993 fishery (Figure 9) was approximately 1.1 thousand lbs/tow-hour. Highest CPUE occurred in the Prince William Sound (Area E) and Yakutat (Area D) fisheries at approximately 2.7 and 2.0 thousand lbs/tow-hour. CPUE for the Alaska Peninsula (Area M), Dutch Harbor (Area O), Bering Sea (Area Q) fisheries were close to the statewide CPUE at 1.0 to 1.2 thousand lbs/tow-hour. By contrast, CPUE in the Kodiak (Area K) fishery was lower at 0.7 thousand lbs/tow-hour.

SCALLOP FISHERY BYCATCH

Top 20 Species Caught By Weight

Scallop gear catches a wide range of species besides scallops. By weight, the top five species encountered were Weathervane scallops (80.2%), starfish (12.6%), skates (2.1%), Bairdi tanner crab (1.6%), and arrowtooth flounder (1.2%). Weathervane scallop shells represented a significant portion of the catch at 6.5% These shells are picked up by the dredges when a vessel tows repeatedly over the same scallop bed, as it processes it's catch and toss the shells overboard. Table 3 lists the top twenty species captured by the dredges. Dungeness crab were caught in 124 of the 4240 hauls sampled, mainly in the Yakutat and Kodiak areas. However, since the observers were not instructed specifically to monitor this species and were inconsistent in recording it on the bycatch forms, complete analysis is not possible.

Crab and Halibut Bycatch By Region

Of the four commercially valuable species -- Tanner crab *Chionoecetes bairdi*, snow crab *C. opilio*, red king crab *Paralithodes camtschaticus*, and halibut *Hippoglossus stenolopis)* --

encountered as bycatch in the 1993 scallop fishery, Tanner crab were by far the most commonly encountered species in each management area (Table 4, Figure 10; bycatch for the Southeast Area A fishery is not included due to confidentiality of data). Highest estimated bycatch of Tanner crabs within a single area occurred in the Bering Sea (Area Q) fishery at approximately 277 thousand crabs, while the bycatch for the next most common crab species within a single area, snow crab in the Bering Sea, was estimated to be approximately 15 thousand crabs. Estimated bycatch of red king crab was approximately 200 or less in all areas considered. Total estimated bycatch of halibut ranged from less than 30 in the Prince William Sound (Area E) fishery to 1,750 in Kodiak (Area K). Since Tanner crab was the predominant commercial species in the bycatch of the 1993 scallop fishery, our examination of bycatch focussed on this species.

Tanner Crab Bycatch By Management Area

Although Tanner crab was the most common commercially valuable species in the bycatch of each area, total estimated Tanner crab bycatch varied widely between areas (Table 4, Figure 10). Relative to other areas, the bycatch of Tanner crabs in the Yakutat (Area D) and Prince William Sound (Area E) fisheries was negligible (estimated at approximately 1.7 and 0.2 thousand crabs, respectively). Estimated Tanner crab bycatch was highest in the Bering Sea (Area Q) fishery (approximately 277 thousand crabs), followed by the Alaska Peninsula (Area M), Kodiak (Area K), and Dutch Harbor (Area O) fisheries (approximately 151 thousand, 101 thousand, and 51 thousand crabs, respectively).

As well as total bycatch, bycatch rates for Tanner crabs also varied widely among management areas. Estimated catch of Tanner crabs per tow-hour was highest in the Alaska Peninsula (Area M) fishery at approximately 160 crabs/tow-hour, followed by the Dutch Harbor (Area O) and Bering Sea (Area Q) fisheries at 120 crabs/tow-hour and 95 crabs/tow-hour, respectively (Figure 11). The estimated catch of Tanner crabs per tow-hour was somewhat lower in the Kodiak (Area K) fishery (19 crabs/tow-hour) and was very low in both the Yakutat (Area D) and Prince William Sound (Area E) fisheries (<2 crabs/tow-hour and <1 crabs/tow-hour, respectively).

Estimated catch of Tanner crabs per round weight pounds of retained scallops was also highest in the Alaska Peninsula (Area M) fishery at 0.14 crabs/lb, followed by the Dutch Harbor (Area O) and Bering Sea (Area Q) fisheries at roughly 0.12 and 0.08 crabs/lb, respectively (Figure 12). The estimate for the Kodiak (Area K) fishery was lower at 0.03 crabs/lb, while the estimates for the Yakutat (Area D) and Prince William Sound (Area E) fisheries were both less than 0.001 crabs/lb.

Given the low bycatch rates for Tanner crabs in the Yakutat and Prince William Sound fisheries, we did not consider these two management areas in any further examinations of Tanner crab bycatch.

VARIATION IN TANNER BYCATCH RATES

In this section we examine the variation in Tanner crab bycatch rates among vessels within the same management area, among trips for single vessels within the same management area, and among management areas within vessels. To maintain confidentiality of data, vessels are identified in this section by randomly assigned letter designations that are unique to each management area considered. Variation of bycatch rates among individual tows within areas and variation in daily bycatch of Tanner crabs by day within areas is presented in a later section ("CHARACTERISTICS OF TANNER CRAB BYCATCH WITHIN INDIVIDUAL AREAS") of this report.

Among Vessels in the Same Management Area

Our presentation here is limited to the Kodiak Management Area (Area K), the Alaska Peninsula Management Area (Area M), and the Bering Sea Management Area (Area Q). Tanner crab bycatch rates in the Yakutat and Prince William Sound Areas (Areas D and E) were low, while presentation of these data for the Southeastern and Dutch Harbor Areas (Areas A and O) could compromise the confidentiality of data.

Estimated Tanner crab bycatch rates for vessels participating in the 1993 Kodiak (Area K) scallop fishery are shown in Figures 13 and 14. Estimated catch of Tanner crabs per tow-hour in the 1993 Kodiak fishery ranged from 3 crabs/tow-hour to 33 crabs/tow-hour (median for vessels = 11 crabs/tow-hour, average for vessels = 16 crabs/tow-hour), while catch of Tanner crabs per round weight pounds of retained scallops ranged from less than 0.01 crabs/lb scallops to over 0.04 crabs/lb scallops (median and average for vessels was 0.02 crabs/lb scallops).

Greatest variation among vessels in Tanner crab bycatch rates for the 1993 scallop fishery was seen in the Alaska Peninsula (Area M) fishery (Figures 17 and 18). Ignoring vessel "M-E", for which only 2 tows were sampled for bycatch, the estimated catch of Tanner crabs per tow-hour for most vessels was roughly 60 crabs/tow-hour, while that for the vessel with the highest bycatch rate was in excess of 350 crabs/tow-hour. Again excluding vessel "M-E", the estimated catch of Tanner crabs per round weight pounds of retained scallops was roughly 0.07 crabs/lb for all but two vessels, while the rate for one vessel was 0.28 crabs/lb. Excluding vessel "M-E", the median catch of Tanner crabs per tow-hour for the vessels was 67 crabs/tow-hour (average = 112 crabs/tow-hour), and the median catch of Tanner crabs per round weight pounds of retained scallops was 0.08 crabs/lb (average = 0.12 crabs/lb).

Sizable variation in the estimated Tanner crab bycatch rates also existed among the vessels participating in the 1993 Bering Sea (area Q) scallop fishery (Figures 17 and 18). Catch of Tanner crabs per tow-hour ranged from 17 crabs/tow-hour to 203 crabs/tow-hour (median = 53 crabs/tow-hour, average = 90 crabs/tow-hour) and catch of Tanner crabs per round weight pounds of retained scallops ranged from 0.02 crabs/lb to 0.15 crabs/lb (median = 0.05 crabs/lb, average = 0.07 crabs/lb).

Among Trips Within Vessels Participating in the 1993 Kodiak Area (Area K) Scallop Fishery

Each of the ten vessels that participated in the 1993 Kodiak Area scallop fishery apportioned their total Kodiak Area fishing effort into two or more trips. So, the Kodiak Area fishery provides an opportunity to examine the variation that exists in Tanner crab bycatch rates among trips for individual vessels in a single management area. Although some vessels showed little variation in estimated catch of Tanner crabs per tow-hour among trips within the Kodiak Area (e.g., vessels "K-A", "K-C", "K-F", and "K-H" in Figure 19), variation among trips for some vessels (vessels "K-H", "K-G", and, in particular, "K-J" in Figure 19) exceeded the variation that was seen among vessels in the Kodiak Area. As we noted above, catch of Tanner crabs per tow-hour in the 1993 Kodiak Area fishery ranged among vessels from 3 crabs/tow-hour to 33 crabs/tow-hour. This rate for single trips in the Kodiak Area of vessel "K-J" ranged from 2 crabs/tow-hour to 81 crabs/tow-hour.

Large variation among trips in estimated number of Tanner crabs per round weight pounds of retained scallops was also seen in three vessels that participated in the Kodiak Area fishery (vessels "K-G", "K-I", and, in particular, "K-J" in Figure 20). Trips for vessel "K-J" alone showed some of the lowest catches of Tanner crabs per round weight pounds of retained scallops (less than 0.01 crabs/lb) as well as the highest catch of Tanner crabs per round weight pounds of retained scallops (0.12 crabs/lb) for a single trip in the Kodiak Area.

Among Management Areas Within Vessels Participating in the 1993 Scallop Fishery

Seven vessels participated in both the Kodiak (Area K) and Alaska Peninsula (Area M) 1993 scallop fisheries. A comparison of estimated Tanner crab bycatch rates between the Kodiak and Alaska Peninsula Areas for six of these vessels is presented here; data from one vessel, for which only two sampled tows were available from the Alaska Peninsula, is not included.

Catch of Tanner crabs per tow-hour for examined vessels was not predictable between areas in terms of either absolute rates or in terms of the ranking of rates relative to other vessels (Figure 21). One vessel (vessel "KM-E" in Figure 21) that fished with some of the lowest catches of Tanner crab per tow-hour among vessels in the Kodiak Area (7 crabs/tow-hour), showed by far the highest catch of Tanner crabs per tow-hour in the Alaska Peninsula (over 350 crabs/tow-hour). On the other hand, another vessel (vessel "KM-C in Figure 21) fished with relatively low catches of Tanner crabs per tow-hour in the Alaska Peninsula (25 crabs/tow-hour), but at relatively high rates in the Kodiak Area (30 crabs/tow-hour). Likewise, catch of Tanner crabs per round weight pounds of retained scallops was not predictable for vessels between areas (Figure 22). Again, vessel "KM-E" is notable for having fished with low catches of Tanner crabs per round weight pounds of retained scallops (0.01 crabs/lb) in the Kodiak Area fished but with the highest bycatch rate (0.28 crabs/lb) in the Alaska Peninsula.

CHARACTERISTICS OF TANNER CRAB BYCATCH WITHIN INDIVIDUAL AREAS

Most of the 1993 scallop fishery closures in the Westward Region were due to bycatch of Tanner crabs. In this section we present data on some of the characteristics and trends seen in Tanner bycatch that were seen in the observer data for two of such areas: the Shelikof District of the Kodiak Management Area (Area K) and the Alaska Peninsula Management Area (Area M).

Shelikof District, Area K

Total Tanner crab bycatch in the Shelikof District from July 1 to August 8, 1993 was estimated to be approximately 51,000 crabs. A total of 10,408 of these crabs were sampled for size, mortality, and injury data. Although data on Tanner bycatch rate were available from all five of the vessels that participated in the Shelikof District fishery, data on size and condition of individual crabs were available for only four of those vessels. To maintain confidentiality of data, vessels are identified in this section by randomly assigned letter designations.

Size Distribution in Tanner Crab Bycatch

Crabs in the size range of 25-140 mm carapace width (cw) were well represented in the Shelikof bycatch and some individuals with cw less than 20 mm and greater than 160 mm were also present (Fig 23). Crabs, principally females, with 80-100 mm cw predominated the bycatch. Crabs greater than 120 mm cw were almost exclusively males, while males and females were roughly equally represented in crabs with cw less than 60 mm.

Observed Mortality in Sampled Tanner Crab Bycatch

Approximately 13% of the sampled bycatch Tanner crabs in the Shelikof fishery were recorded as dead or moribund before being discarded. The mortality rate for the remaining crabs after discarding, or of dredge-impacted crabs that did not arrive on deck, is unknown. Incidence of observed mortality varied with size of crabs in a roughly "U-shaped" trend, with highest observed-mortality rates occurring in small and large crabs and lowest rates occurring in intermediate-sized crabs (Figure 24). This trend is apparent when the observed-mortality-at-size data from all vessels is pooled (the open squares in Figure 24). Pooling data from all vessels hides the variability in observed-mortality-at-size that exists among vessels, however. Local regression binomial-model smoothing of the observed- mortality-at-size data from each vessel (the four curves without cross-hatches in Figure 24) indicates that, although observed mortality-at-size varied greatly in level among vessels, the general "U-shaped" observed-mortality-at-size relationship was present in the data from each sampled vessel.

Whether differences in observed-mortality-at-size among vessels is due to differences in gear or conditions among vessels or to an "observer effect" is unknown. Since differences exist for unknown reasons among observed vessels in the level of observed-mortality-at-size, we believe that the observed-morality-at-size trend can best be estimated from these data by the overall trend among vessels without pooling the data from vessels and without weighting by the sample sizes for vessels (the cross-hatched curve in Figure 24). This final estimate of the observed-mortality-

at-size trend indicates that crabs with cw less than 35 mm have observed-mortality rates of 30% or greater, while for those in the 80-100 mm cw range the observed-mortality rate is only slightly over 10%. For crabs with cw greater than 100 mm, the observed-mortality rate increases with size up to approximately 20%.

Observed New-injury Incidence in Sampled Tanner Bycatch

Presence of new injuries in sampled crabs to the carapace, abdomen, rostrum, left and right chela, and each of the 8 walking legs were recorded by observers. We condensed the analysis of these data by considering only the "number of new injuries" (i.e., the number out of the 13 inspected anatomical parts that received new injuries) in each crab. Incidence of numbers of new injuries in the sample of bycatch crabs from the Shelikof fishery is shown in Figure 25. New injuries were observed in 28% of the sampled crabs. Of those crabs with observed new injuries, those with one newly injured part were most common (15% of sampled crabs). Crabs with four or more new injuries were rare, but crabs with five to 13 newly injured parts were present in the sample. Observed mortality was positively correlated to the number of newly injured parts (Figure 25): 6% of the crabs with no new injuries were observed dead, 19% of crabs with one newly injured part were observed dead, while those with five or more newly injured parts had observed mortality rates in excess of 90%.

Presence of new injuries varied with size of crabs in a "U-shaped" pattern similar to that seen for mortality rates (Figure 26). We estimated the trend in these data by using the same methods as were outlined above for our analysis of observed-mortality-at-size. Although the "U-shaped" pattern is apparent in the pooled data from all vessels (the open squares in Figure 26), local regression binomial-model smoothing of the new-injury-presence-at-size data for each vessel individually indicates that, for a given size of crab, the proportion of crabs in which new injuries were observed varied among vessels (the four curves without cross-hatches in Figure 26). Data from each of the vessels generally showed the "U-shaped" relationship between size of crabs and the proportion of crabs with new injuries, however. Our final estimate of the new-injury-presence-at-size trend was based on the overall trend among vessels without pooling the data from vessels and without weighting by the sample sizes for vessels (the cross-hatched curve in Figure 26). Our final trend estimate indicates that 50% or more of the bycatch crabs with cw less than 40 mm sustained new injuries, while roughly 30% of those with cw between 80 and 100 mm sustained new injuries. Incidence of new injuries tend to increase with sizes beyond 100 mm cw, up to approximately 35%.

Relationship Between Tanner Crab Bycatch Rate and Scallop CPUE in Individual Tows

Scallop CPUE (round weight pounds of retained scallops per tow-hour) in the Shelikof District was 934 lbs/tow-hour, while Tanner crab bycatch rate (number of crabs per tow-hour) in sampled tows was 40 crabs/tow-hour. Scallop CPUE and Tanner bycatch rate varied widely among individual tows, however. Although very "noisy", there is a general positive relationship between Tanner crab bycatch rate and scallop CPUE: tows with high bycatch rates of Tanner crabs were often associated with high scallop CPUE (Figure 27).

Trends in Daily Bycatch of Tanner Crabs

Daily bycatch of Tanner crabs in the 1993 Shelikof District fishery was estimated for July 24 through August 4 (Figure 28). Our presentation is limited to this period because all five vessels that participated in the Shelikof District fishery fished during this period. Estimated total daily Tanner crab bycatch varied between roughly 1,000 to 3,000 crabs per day from July 24 through August 1. Estimated bycatch rose sharply to nearly 7,000 crabs on August 2, however, and remained well above 3,000 crabs per day through August 4. Although not presented in this report, daily trends in Tanner crab bycatch per tow-hour and Tanner crab bycatch per round weight pounds of retained scallops generally follow the trend seen in estimated daily total Tanner bycatch.

Alaska Peninsula, Area M

Total Tanner crab bycatch for the eight vessels participating in the Alaska Peninsula fishery from July 25 to October 21, 1993 was estimated to be approximately 151,000 crabs. A total of 11,319 of these crabs were sampled for size, mortality, and injury data. Although bycatch data was available from seven participating vessels, we restricted our comparisons of condition of bycatch Tanner crabs among vessels to those vessels with more than 55 sampled hauls (the number of hauls sampled for bycatch in the remaining vessels was 10 or less). The letter designations that are used to identify individual vessels in this section are the same as those used to identify the vessels participating in the Alaska Peninsula fishery in the section (above) on **VARIATION IN TANNER CRAB BYCATCH RATES**.

Size Distribution in Tanner Crab Bycatch

In contrast to the Shelikof District, Tanner crabs in the bycatch for the Alaska Peninsula fishery were dominated by small crabs (<50 mm cw), with approximately 2/3 of the crabs having sizes in the range of 15-35 mm cw (Figure 29). Although some legal-sized males were present in the bycatch samples, crabs with cw greater than 110 mm were rare.

Observed Mortality in Sampled Tanner Crab Bycatch

Approximately 35% of the sampled bycatch Tanner crabs from the Area M fishery were recorded as dead or moribund before being discarded. As noted earlier, we stress that the mortality rate for the remaining crabs after discarding, or of dredge-impacted crabs that did not arrive on deck, is unknown. Similar as to was seen in the Shelikof District Tanner bycatch, incidence of observed mortality varied with size of crabs in a roughly "U-shaped" fashion, with highest observed-mortality rates occurring in small and large crabs and lowest observed-mortality rates occurring in intermediate-sized crabs (Figure 30). The higher observed-mortality rate in the Alaska Peninsula bycatch as compared to the Shelikof District bycatch may be accounted for by this size-mortality relationship coupled with the predominance of small crabs in the Alaska Peninsula bycatch.

As in the case with the Shelikof data (above), pooling the data from all vessels shows the "U-shaped" trend in proportion observed dead at size (the open squares in Figure 30), but local

regression binomial-model smoothing of the observed-mortality-at-size data within vessels (the four curves without cross-hatching in Figure 30) shows that variation exists among vessels in the level of this trend. As with the Shelikof data, we cannot determine whether differences in observed-mortality rates among vessels is due to differences in gear or conditions among vessels or to an "observer effect". Our final estimate of the observed-mortality-at-size trend was based on the overall trend among vessels without pooling the data from vessels and without weighting by the sample sizes for vessels (the cross-hatched curve in Figure 30). Our final estimate of the observed-mortality-at-size trend indicates that 30-40% of small (<40 mm cw) crabs, 20% of the intermediate-sized (70-90 mm cw) crabs, and 40% or more of the larger (>120 mm cw) crabs in the Alaska Peninsula Tanner bycatch were dead or moribund before being discarding.

Observed New Injury Rate Incidence in Sampled Tanner Bycatch

As in the Shelikof District analysis, we condensed the analysis of incidence of new injuries to 13 inspected anatomical parts by considering only the "number of new injuries" (i.e., the number out of the 13 inspected anatomical parts that received new injuries) in each crab. Incidence of numbers of new injuries in the sample of bycatch crabs is shown in Figure 31. At least one newly injured part was observed in 59% of the sampled crabs. The rate of new injury incidence was higher than was observed for the Shelikof District -- a difference that may largely be attributable to the smaller size of crabs in the Alaska Peninsula bycatch (see below). Trends in incidence of numbers of newly injured parts and the positive relationship between observed-mortality rate and number of newly injured parts is similar as to was seen in the Shelikof bycatch.

As in the Shelikof District bycatch, the proportion of Alaska Peninsula bycatch crabs with new injuries varied with size of crabs in a "U-shaped" pattern similar to that seen for mortality rates. Figure 32 shows the proportion of crabs of given sizes with new injuries in the data pooled from all vessels (the open squares in Figure 32), the local regression binomial-model smoothings of the new-injury-presence-at-size data for each vessel individually (the four curves without cross-hatching in Figure 32), and our final estimate of the new-injury-presence-at-size trend based on the overall trend among vessels without pooling the data from vessels and without weighting by the sample sizes for vessels (the cross-hatched curve in Figure 32). Our final trend estimate indicates that 60% or more of the small (<40 mm cw) and large (>120 mm cw) bycatch crabs sustained new injuries, while intermediate-sized 70-90 mm cw) crabs sustained new injuries at a rate of roughly 40%.

Relationship Between Tanner Crab Bycatch Rate and Scallop CPUE in Individual Tows

Scallop CPUE (round weight pounds of retained scallops per tow-hour) in the Alaska Peninsula was 1,132 lbs/tow-hour, while Tanner crab bycatch rate (number of crabs per tow-hour) in sampled tows was 161 crabs/tow-hour. Scallop CPUE and Tanner bycatch rate varied widely among individual tows, however, and particularly high rates of Tanner bycatch (1,000 to 2,600 crabs/tow-hour) were observed in individual tows. All tows with observed Tanner bycatch rates in excess of 1,000 crabs/tow-hour were associated with high scallop CPUEs (1,500 to 2,300 lbs/tow-hour; Figure 33).

Trends in Daily Bycatch of Tanner Crabs

Daily bycatch of Tanner crabs in the 1993 Alaska Peninsula fishery was estimated for October 7 to through October 20. Our presentation is limited to this period due to confidentiality of data outside of this period. Estimated total daily Tanner crab bycatch was roughly 200 to 1,000 crabs per day from October 1 through October 12. However, estimated daily bycatch rose dramatically to over 18,000 crabs on October 13, remained above 15,000 crabs per day through October 18, and peaked on October 18 at 33,000 crabs (Figure 34). Estimated Tanner crab bycatch for the 6 day period of October 13 through October 18 was 133,000 crabs -- nearly 90% of the 151,000 total Tanner crab bycatch for the entire 1993 Alaska Peninsula fishery. Although not presented in this report, daily trends in Tanner crab bycatch per tow-hour and Tanner crab bycatch per round weight pounds of retained scallops generally follow the trend seen in estimated daily total Tanner bycatch.

EVIDENCE FOR THE RECAPTURE OF PREVIOUSLY DISCARDED TANNER CRAB

The possibility exists that Tanner crab are repeatedly recaptured by dredges working the same area. If in fact, substantial recaptures occur total bycatch estimates would be biased high. An analysis of trends in crab bycatch from the Alaska Peninsula fishery showed no evidence of substantial recaptures, however the recovery of discarded scallop shells does provide some baseline, maximum values for crab recapture. See appendix H for a further discussion.

SCALLOP OBSERVER PROGRAM JUSTIFICATION

Our examination of Tanner crab bycatch data from the 1993 scallop fishery observer program shows that:

1) Scallop dredges can capture substantial numbers of Tanner crabs with sizes ranging from 15 mm or less in carapace width (cw) up to legal size or larger. Tanner crab bycatch rates in excess of 1,000 crabs per tow-hour and up to 2,600 crabs per tow-hour were observed. Total bycatch of Tanner crabs in the 1993 scallop fishery was estimated to be over 580,000 Tanner crabs.

2) Mortality rates observed in bycatch Tanner crabs that are brought on board scallop vessels can range from 10% to 40% or more depending on the size of crab; highest observed mortality rates occur in small (<40 mm cw) and large (>120 mm cw) crabs, while lowest observed mortality rates are observed in the intermediate size range. Variation among management areas in observed-mortality rates of bycatch Tanner crabs can be largely accounted for by differences among areas in the predominant size-class of the bycatch crabs. Since this is only the rate at bycatch crabs are observed as dead or moribund before being discarded, the observed-mortality rates for bycatch crabs should be considered <u>minimum</u> mortality estimates. Long term

mortality and mortality in bycatch crabs that were not landed on board a vessel or which were otherwise impacted by scallop dredging remains unknown.

3) Incidence rates of new injuries in bycatch Tanner crabs that are brought on board vessels can range from 20% to 60% or more depending on the size of crab; highest incidence of new injuries occurs in small (<40 mm cw) and large (>120 mm cw) crabs, while lowest incidence of new injuries are observed in the intermediate size range. Variation among management areas in incidence rates of new injuries in bycatch Tanner crabs can be largely accounted for by differences among areas in the predominant size-class of the bycatch crabs. Presence of new injuries is clearly related to observed mortality in crabs prior to being discarded; it seems reasonable to assume that it is also associated with long term mortality after discarding.

4) Wide variation in Tanner bycatch occurs at all levels examined, from comparisons of individual tows to comparisons between areas. Overall bycatch rates for a single area cannot be generalized to all vessels fishing in the area and bycatch rates for one vessel cannot be generalized from one trip to another within the same management area. Tanner crab bycatch for individual vessels can change unpredictably between areas; we have seen that a vessel that is among the "cleanest" vessels in one management area can be by far the "dirtiest" in another management area. Wide variation can also occur in the daily Tanner crab bycatch; daily Tanner crab bycatch in a management area can increase dramatically in just one day to such magnitudes that projected fishery closure dates based on earlier bycatch trends are inadequate.

5) Highest rates of Tanner crab bycatch by tow in areas examined were found to be associated with high CPUE of scallops. This trend in the bycatch data indicates that scallop CPUE alone does not provide an incentive for the fleet to avoid dredging in areas of high Tanner crab abundance.

Based on these findings, we feel that 100% observer coverage of vessels participating in the scallop fishery is fully justified and necessary to protect non-target crab species from the adverse affects of scallop dredging.

Besides bycatch issues, the observer program has many positive aspects. It documents marine phenomena of all types, such as an incredible tow with a half ton of skate egg cases. More important, it allows the collection of timely scallop catch reports needed to monitor the fishery, and it gathers the biological information on scallops needed to establish growth parameters for the different regions of the state, documents spawning timing and the recruitment of new beds into the fishery so that the management of this fishery can be on a sound scientific basis. It also fosters lively contact between the Department and the industry.

Table 1. Scallop observer training record, 1993 and 1994. Fish and Game personnel trained were not officially certified and did not enter the active scallop observer pool.

Training Agency	Date	Number Certified	Number Approved but not attending	Personnel trained	
				Contract Observer	ADF&G
UAA	June 28-29, '93	12	4	12	0
UAA	Aug. 10-11, '93	5	5	5	0
UAA	Oct. 26-27, '93	2	0	2	0
ADF&G	Oct. '93	2	n/a	2	0
UAA	Jan. 5-6, '94	3	6	3	0
ADF&G	Jan. 94	4	n/a	0	4

Table 2. Scallop ages statewide from 1993 observer program.

Area	Height (mm)		Age (years)	
	Mean	Median	Mean	Median
Yakutat	117.7	116	6.3	6
Prince William Sound	123.5	123	6.6	7
Kodiak	142.8	143	8.4	8
Alaska Peninsula	121.3	120	7.6	8
Dutch Harbor	128.0	127	5.5	5
Bering Sea	146.3	150	9.8	10

Table 3. Twenty most frequently caught species by weight, as recorded by the 1993 scallop observer program.

Rank	Species	Scientific Name	% of Catch
1	Weathervane scallop	*Patinopecten caurinus*	80.2%
2	Starfish	Class Stelleroidea	12.6%
3	Weathervane scallop shells	*P. caurinus*	6.5%
4	skates	Family Rajidae	2.1%
5	Tanner crab	*Chionoecetes Bairdi*	1.6%
6	Arrowtooth Flounder	*Atherestes stomias*	1.2%
7	skate egg cases	Family Rajidae	0.9%
8	basket star	*Gorgonocephalus caryi*	0.9%
9	flathead sole	*Hippoglossoides elassodon*	0.7%
10	snow crab	*Chionoecetes opilio*	0.7%
11	sea anemone	Order Actiniaria	0.5%
12	rock sole	*Lepidosetta bilineata*	0.5%
13	octopus	Family octopodoteuthidae	0.3%
14	snails	Order Gastropoda	0.3%
15	hybrid Tanner	*C. Bairdi x opilio*	0.3%
16	Hermit crab	Family Paguridae	0.3%
17	Pacific cod	*Gadus macrocephalus*	0.2%
18	rex sole	*Glyptocephalus zachirus*	0.2%
19	bay scallops	*Chlamys sp.*	0.1%
20	butter sole	*Isopsetta isolepis*	0.1%

Table 4. Bycatch record of commercially important species by Region, 1993 scallop fishery. An additional 42,000 *C. Bairdi* were captured in the Semidi Islands in Jan.-Feb. 1994.

	Bycatch Estimates by Species					
Region	*C. Baird*	Std. Error	*C. opilio*	Std. Error	Red King Crab	Halibut
Yakutat	1,700	120	0		40	99
Prince William Sound	200	30	0		0	27
Kodiak	100,700	3590	0			1750
Eastside District	30,800	1960	0		9	
Shelikof Strait	50,700	1710	0		0	
Semidi Islands	19,000	2480	0		6	
Alaska Peninsula	150,900	6970	0		26	327
Dutch Harbor	50,800	7000	0		45	1497
Bering Sea	276,500	5460	15,000	310	212	327
Areas Combined	580,600		15,000		338	4027

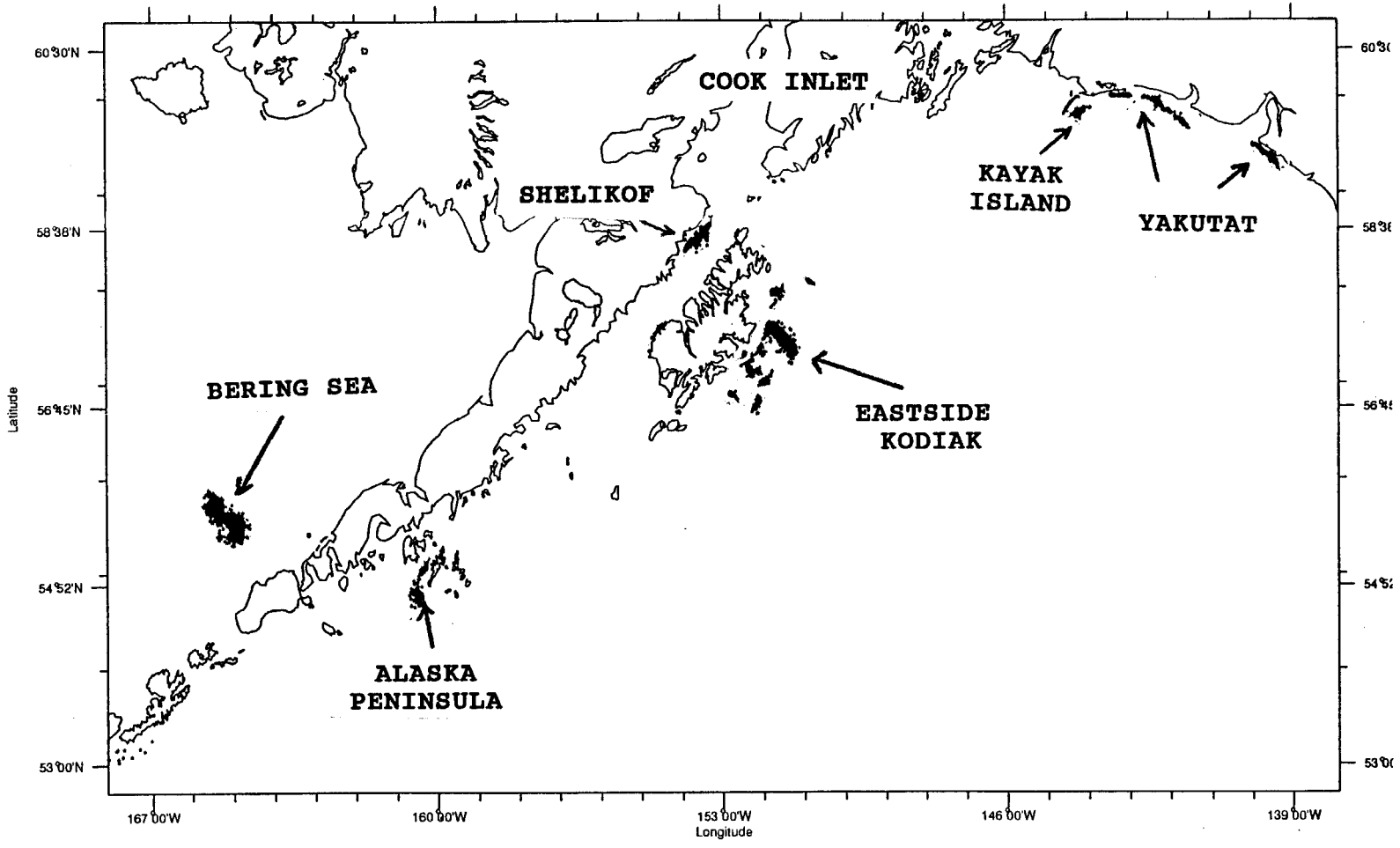
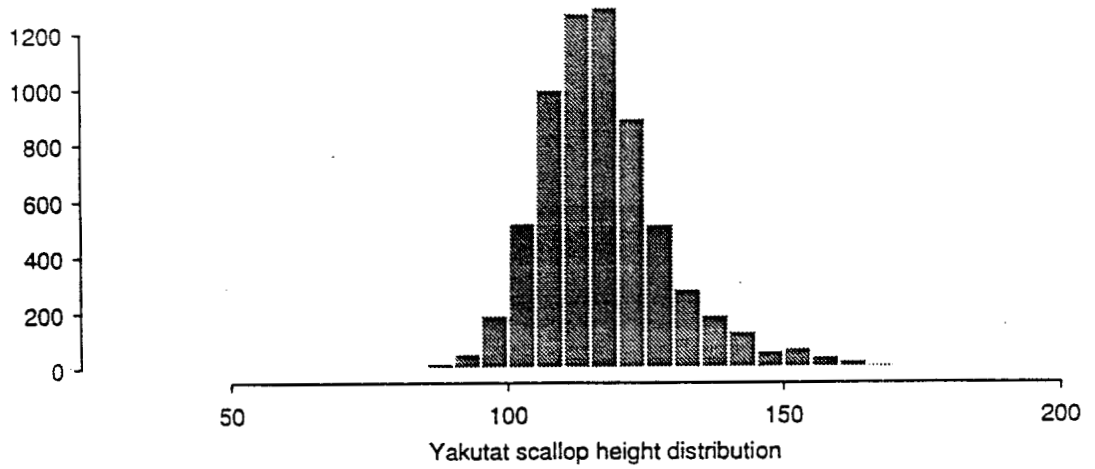
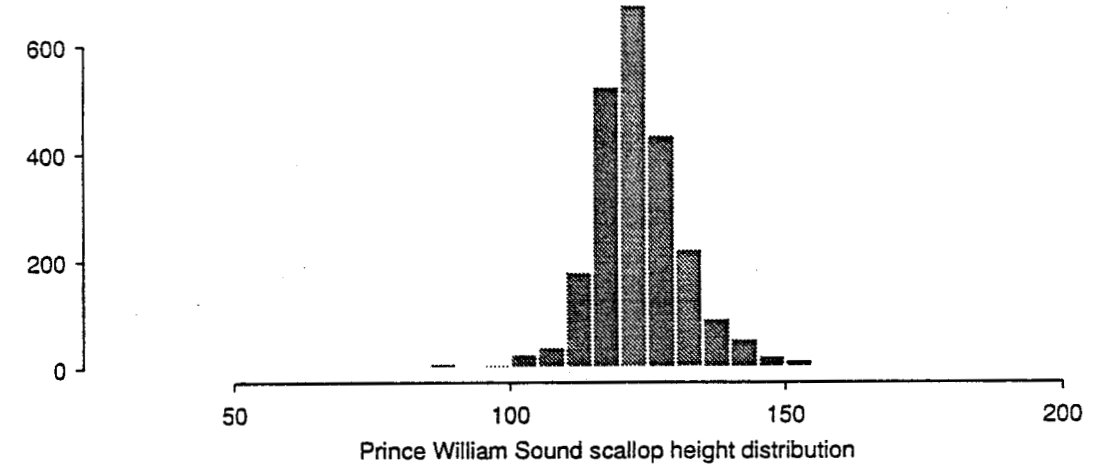
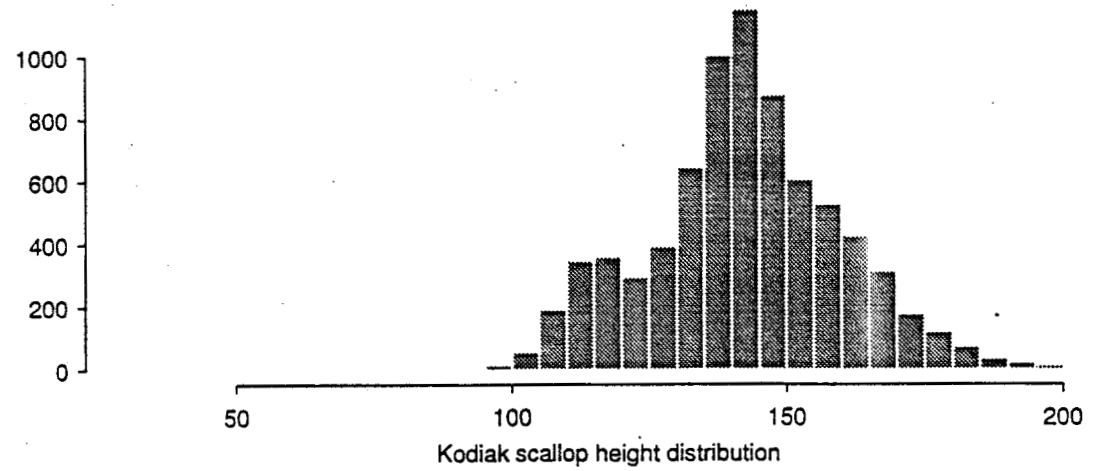


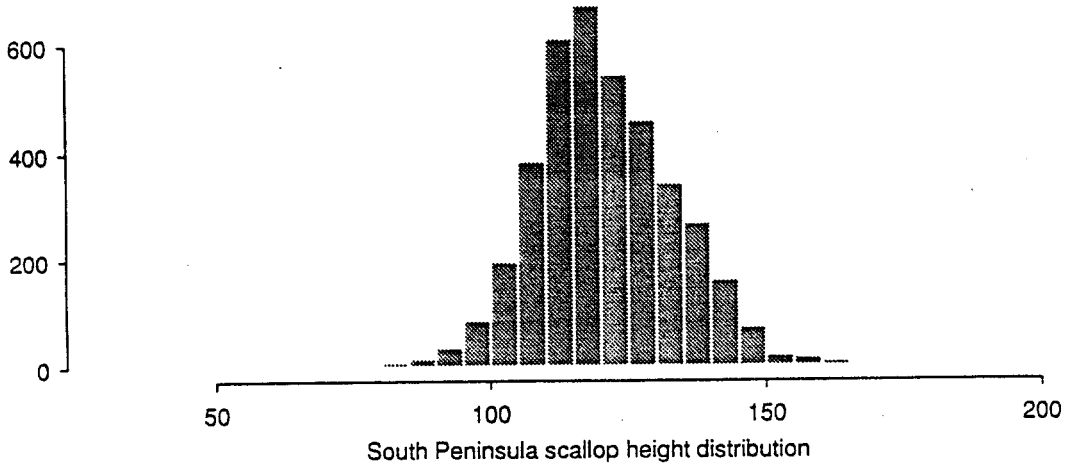
Figure 1. Areas fished statewide during the 1993 scallop fishery. Fishing in Southeast Alaska and parts of the Dutch Harbor area remain confidential.

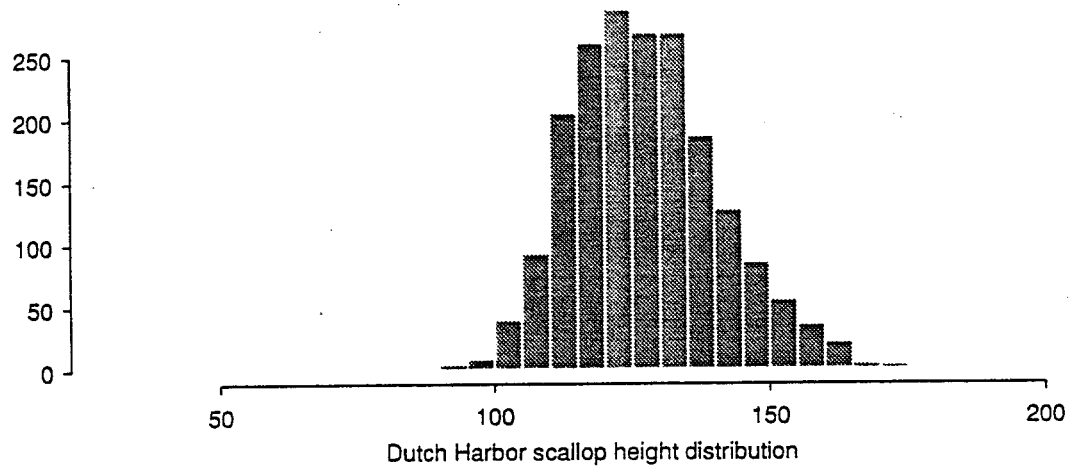


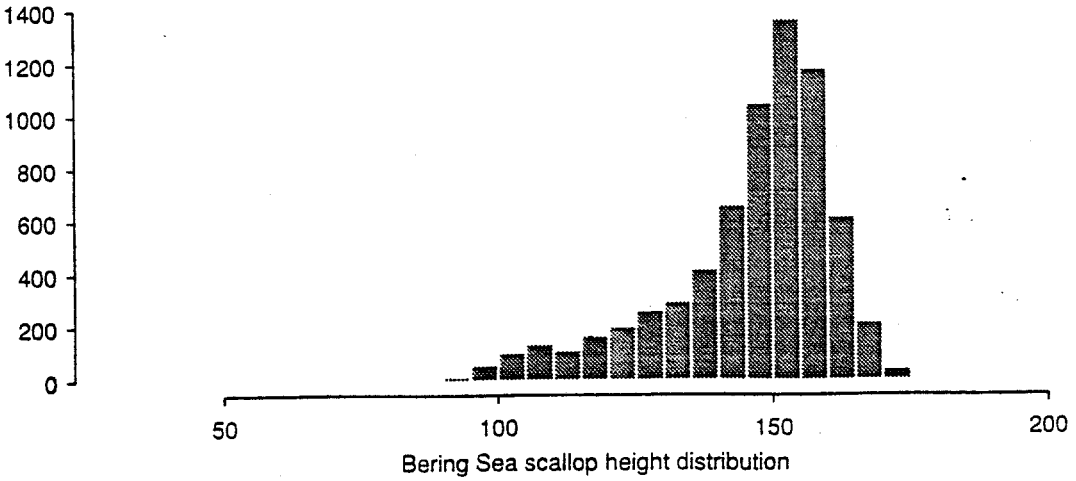




Figures 2-4. Size frequency of scallops in the Yakutat, Prince William Sound, and Kodiak Management Areas.







Figures 4-6. Size frequency of scallops in the Alaska Peninsula, Dutch Harbor, and Bering Sea Management Areas.

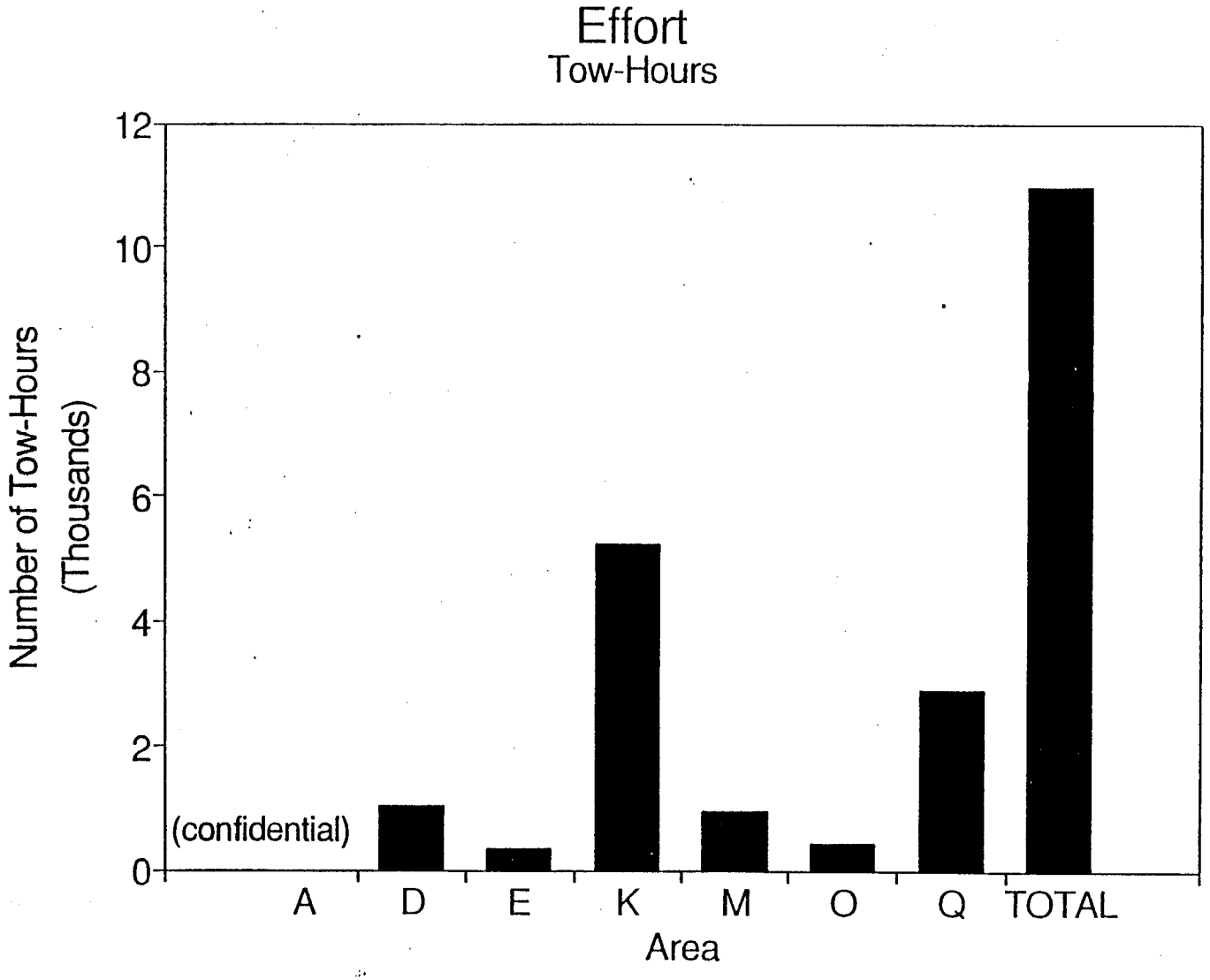


Figure 7. Fishing effort in tow-hours by management area in the 1993 scallop fishery.

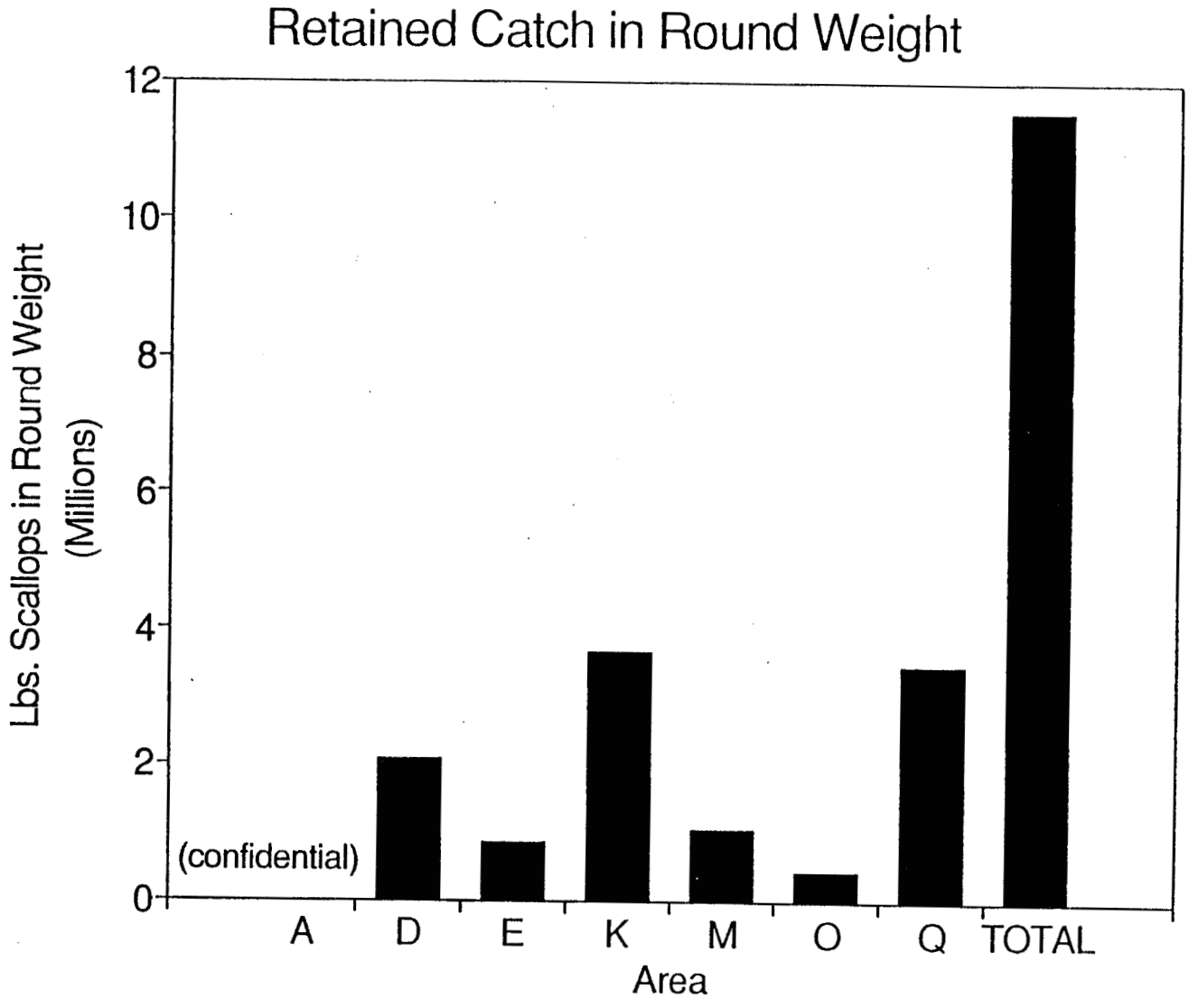


Figure 8. Round weight pounds of retained scallops by management area in the 1993 scallop fishery.

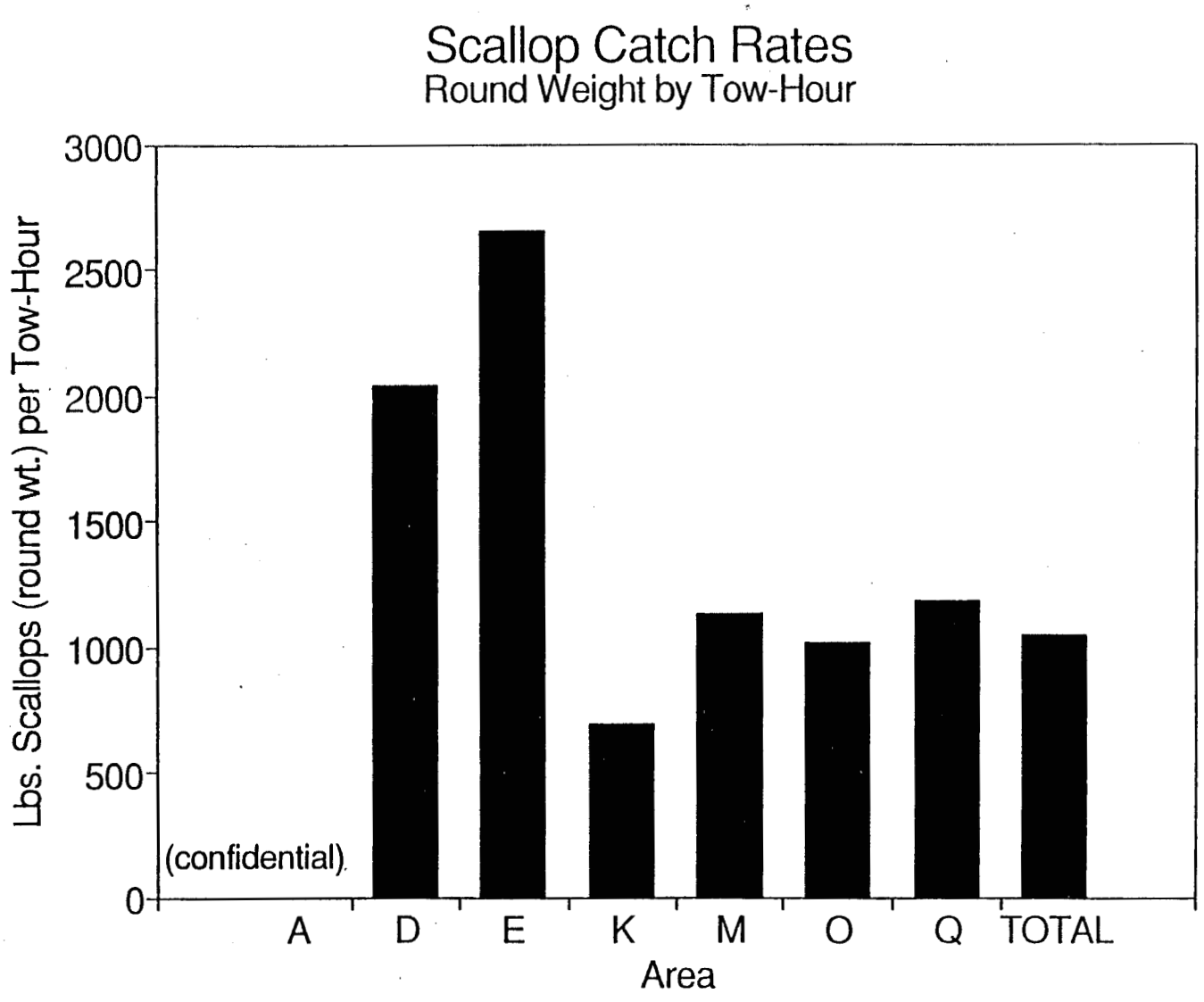


Figure 9. Scallop CPUE (round weight pounds of retained scallops per tow-hour) by management area in the 1993 scallop fishery.

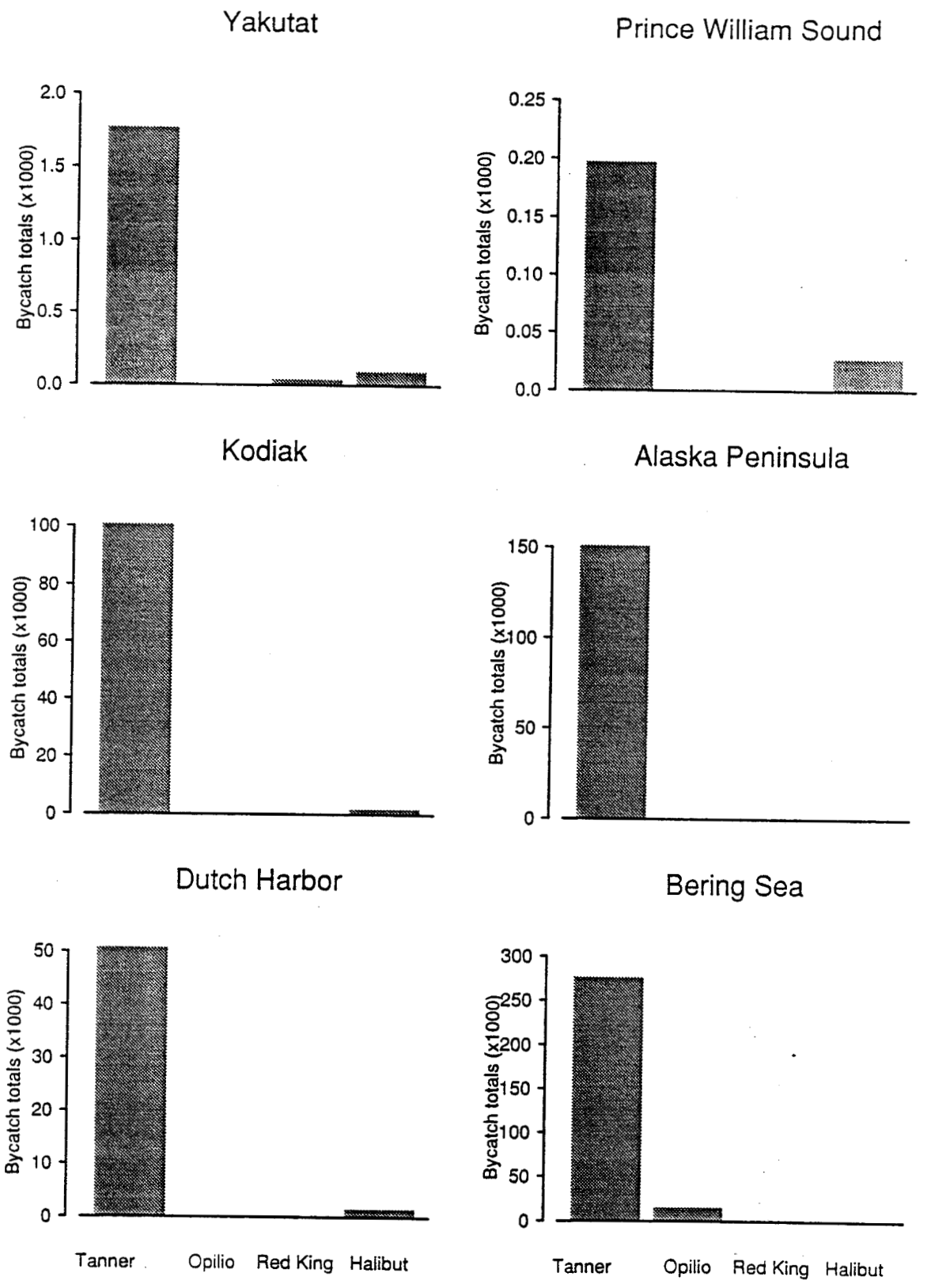


Figure 10. Bycatch of Tanner crab, snow crab, red king crab, and halibut by management area in the 1993 scallop fishery. The Southeastern Area is not included here due to confidentiality of data.

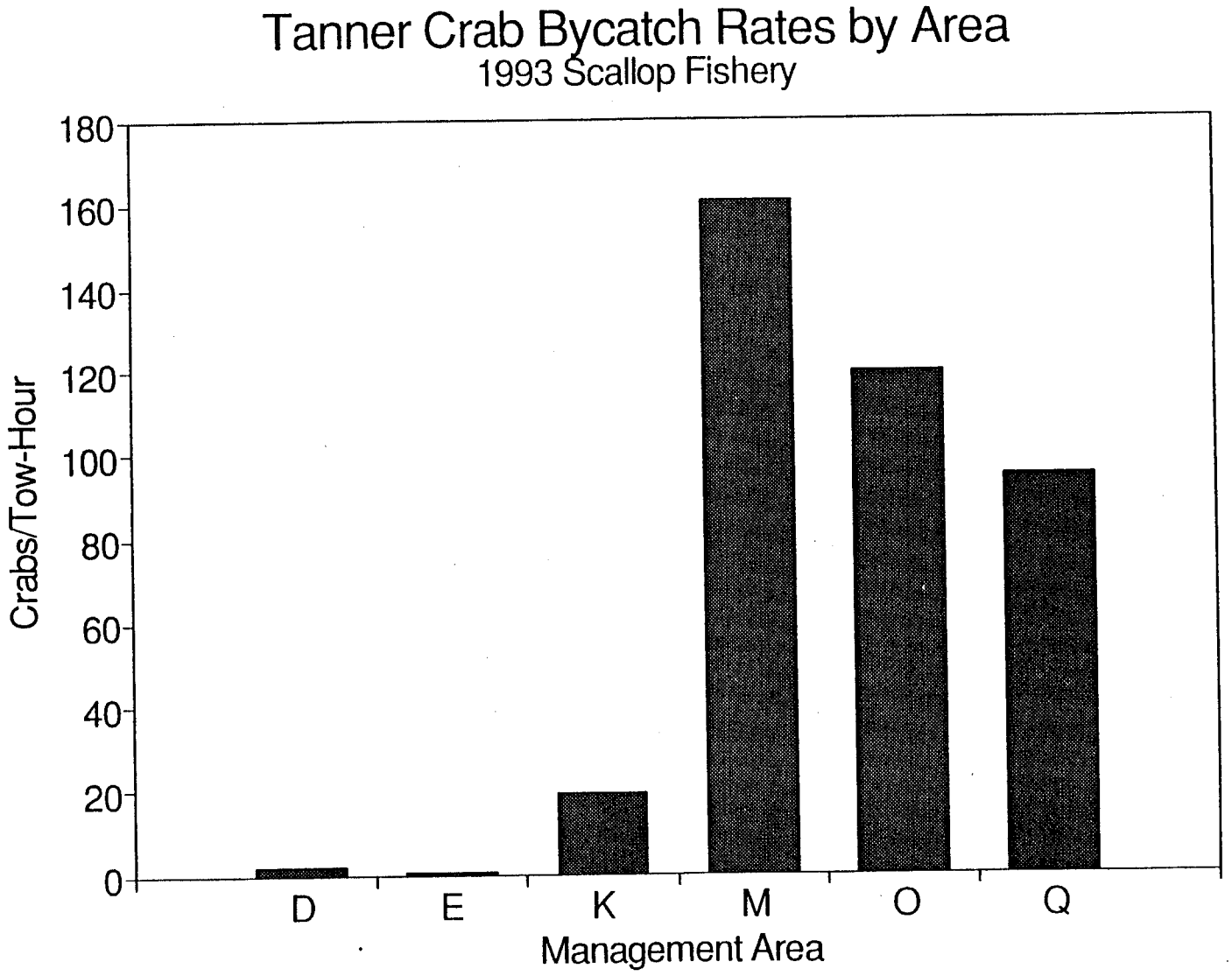


Figure 11. Catch of Tanner crabs per tow-hour by management area in the 1993 scallop fishery. The Southeastern Area is not included here due to confidentiality of data.

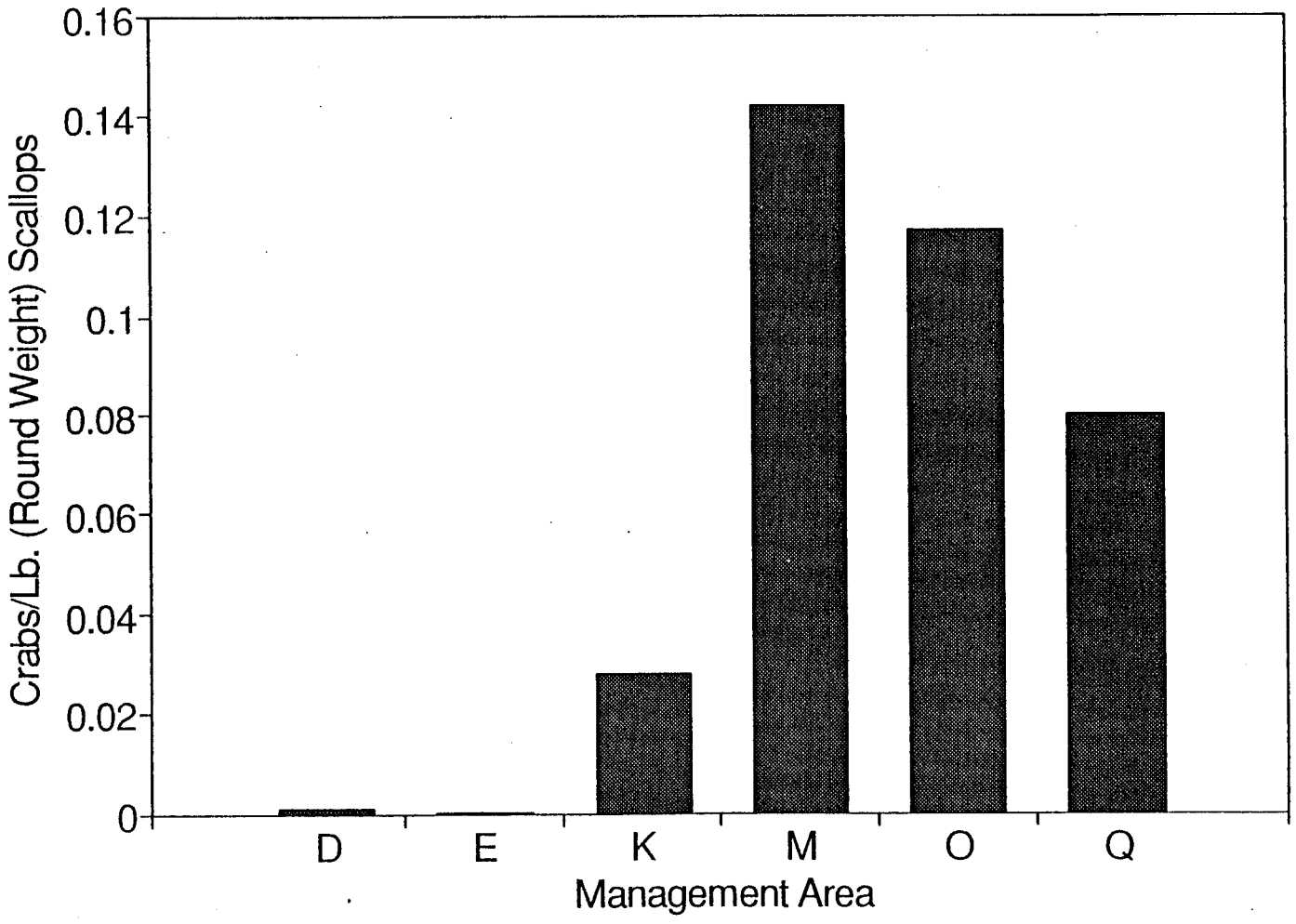


Figure 12. Catch of Tanner crabs per round weight pounds of retained scallops by management area in the 1993 scallop fishery. The Southeastern Area is not included here due to confidentiality of data.

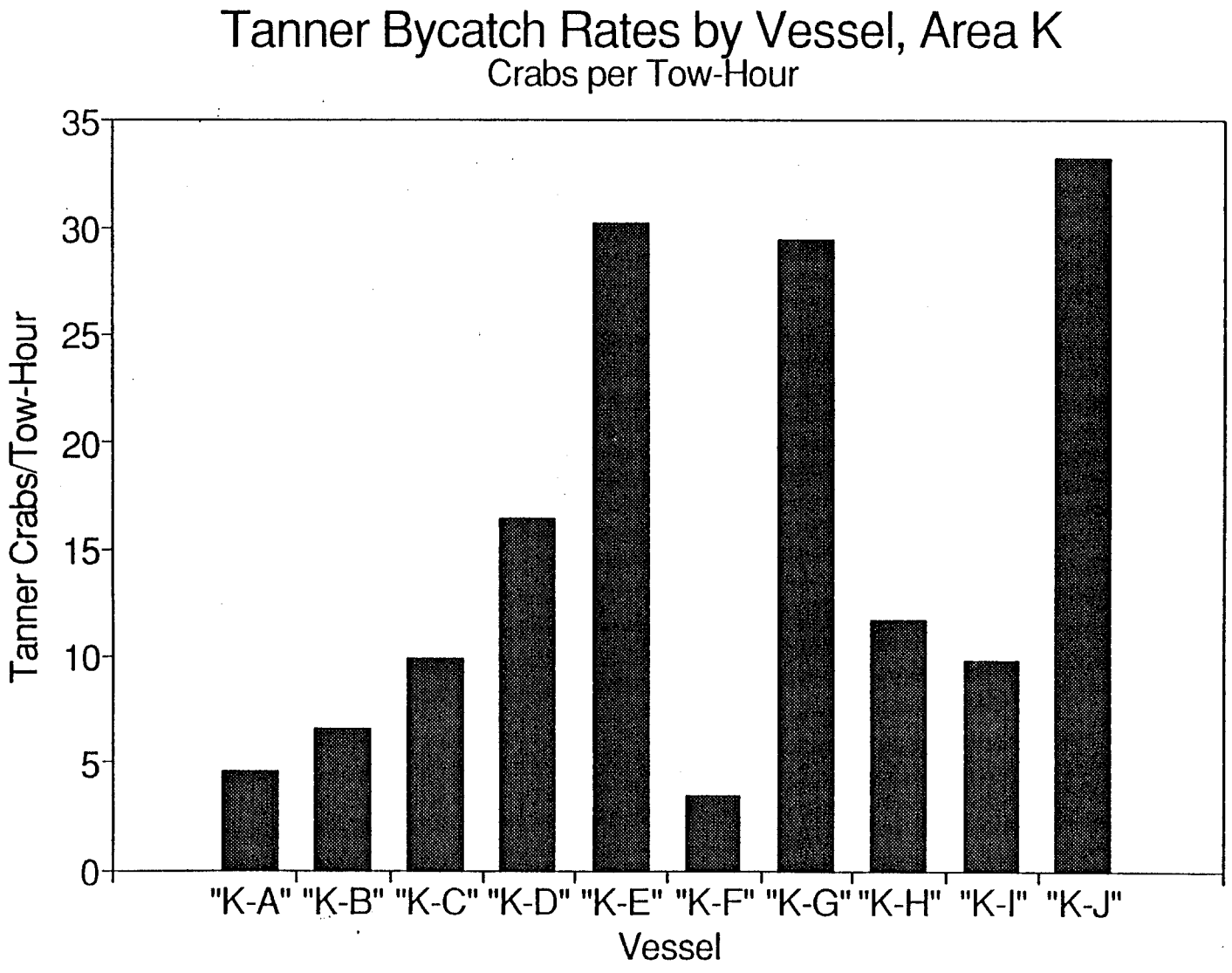


Figure 13. Number of Tanner crabs per tow-hour in the bycatch of the ten vessels participating in the 1993 Kodiak (Area K) scallop fishery.

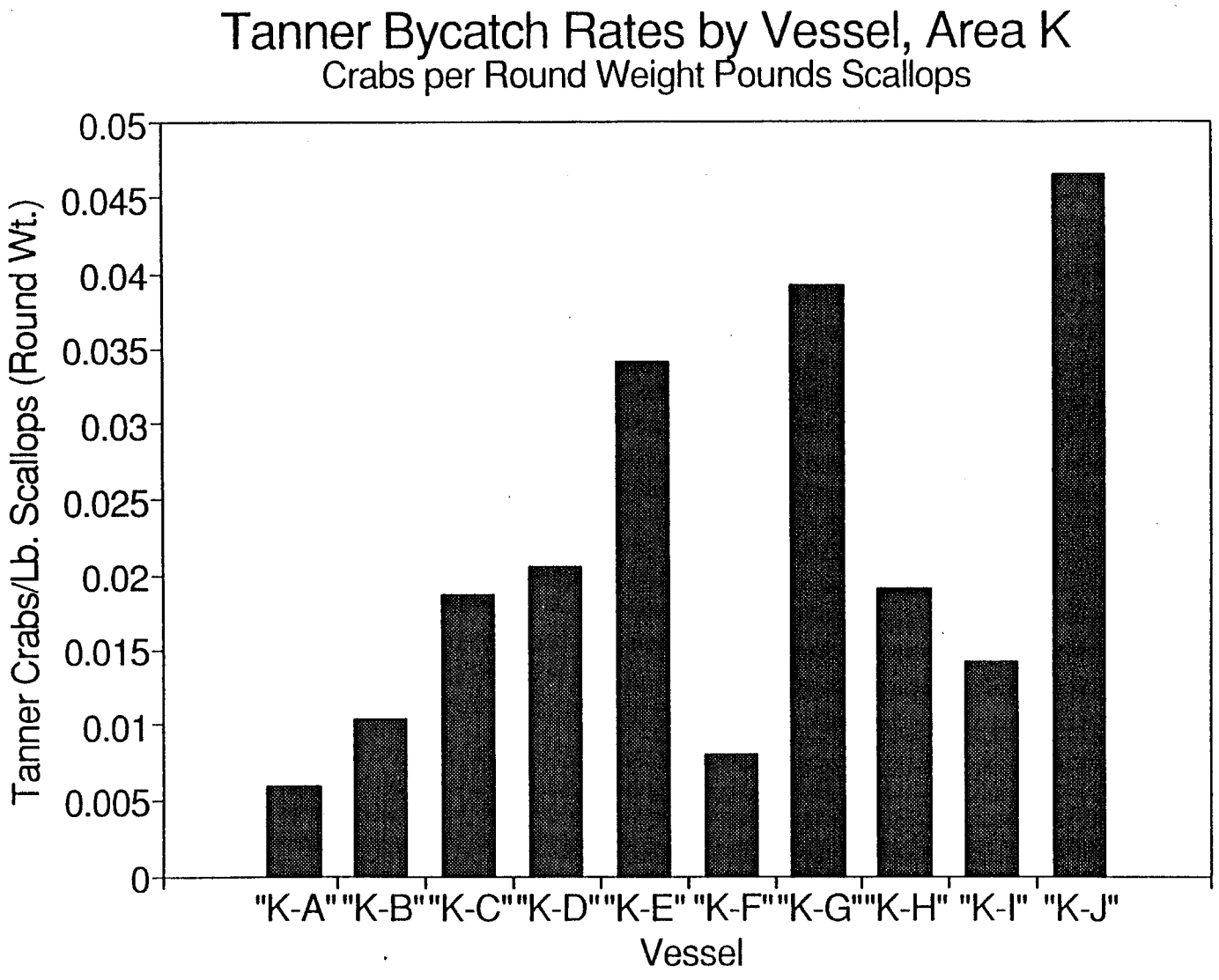


Figure 14. Number of Tanner crabs per round weight pounds of retained scallops in the bycatch of the ten vessels participating in the 1993 Kodiak (Area K) scallop fishery.

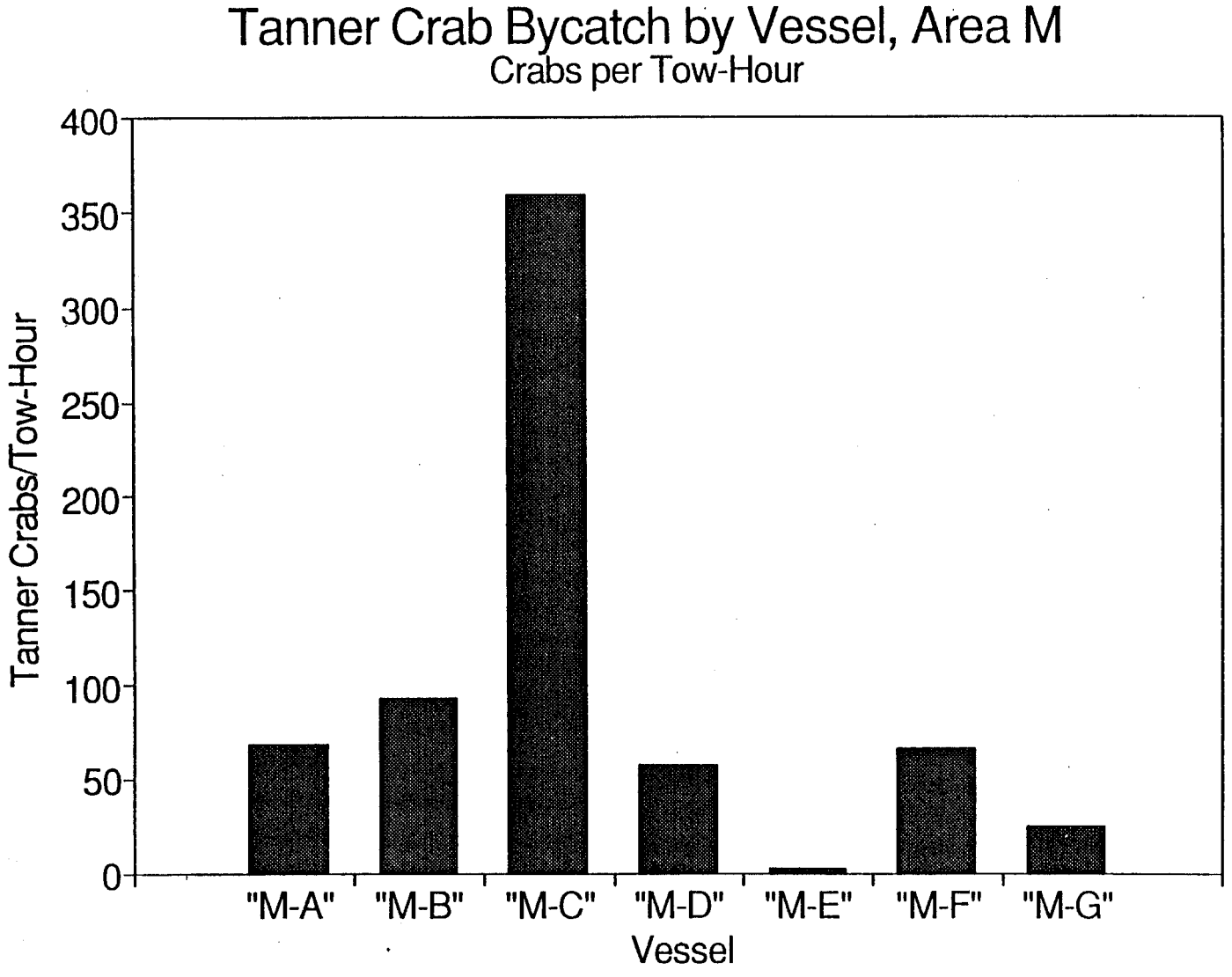


Figure 15. Number of Tanner crabs per tow-hour in the bycatch of the seven vessels participating in the 1993 Alaska Peninsula (Area M) scallop fishery.

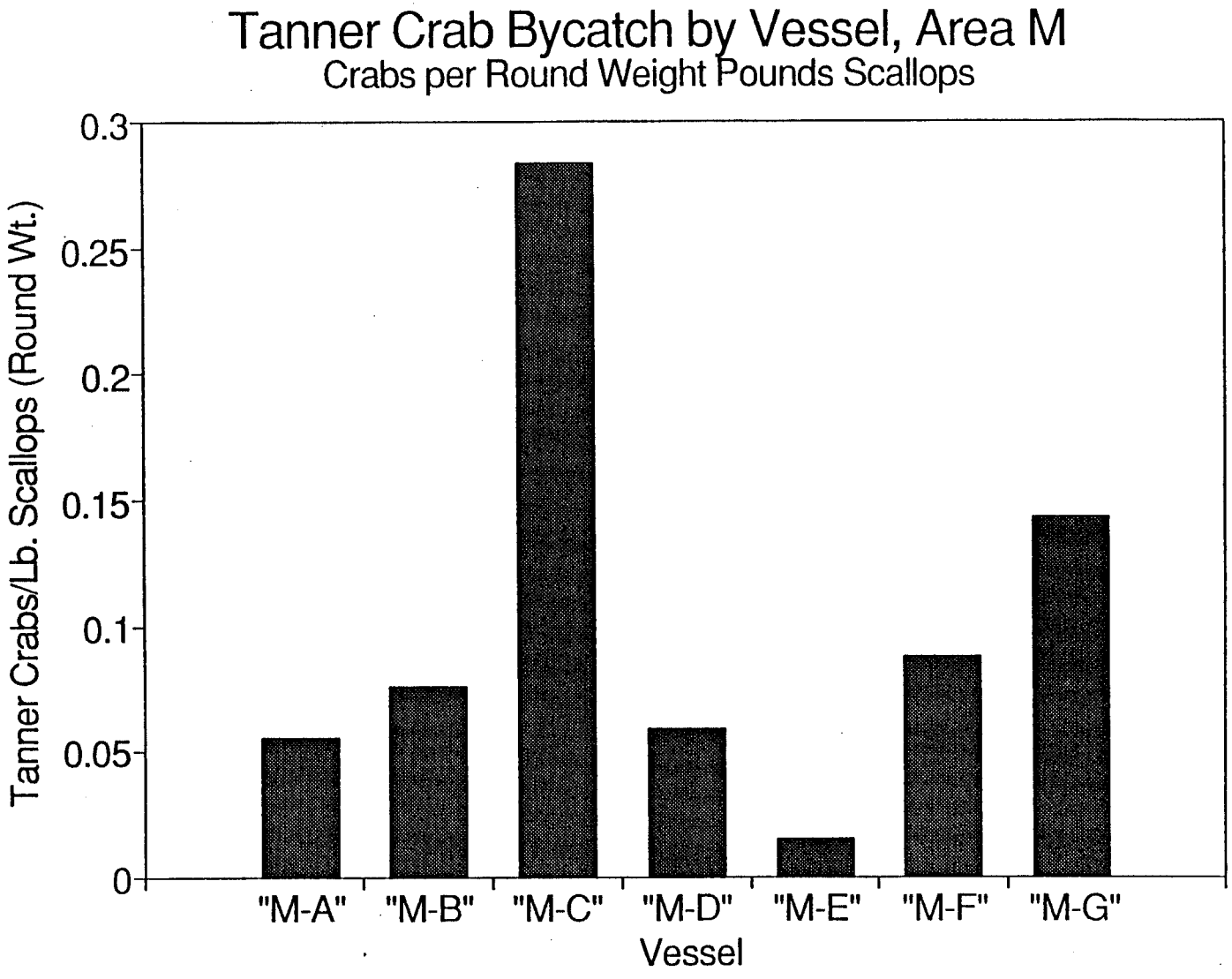


Figure 16. Number of Tanner crabs per round weight pounds of retained scallops in the bycatch of the seven vessels participating in the 1993 Alaska Peninsula (Area M) scallop fishery.

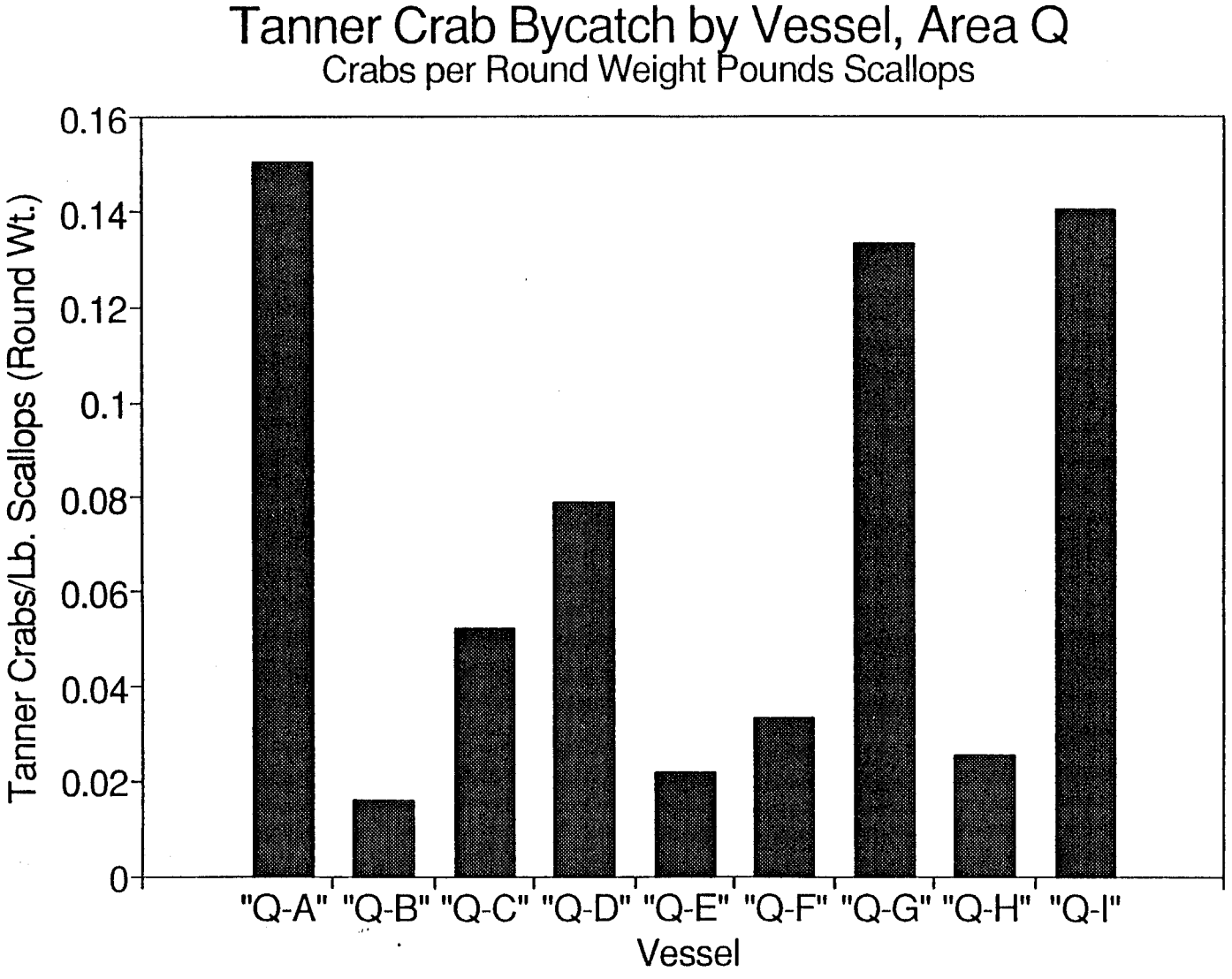


Figure 17. Number of Tanner crabs per tow-hour in the bycatch of the nine vessels participating in the 1993 Bering Sea (Area Q) scallop fishery.

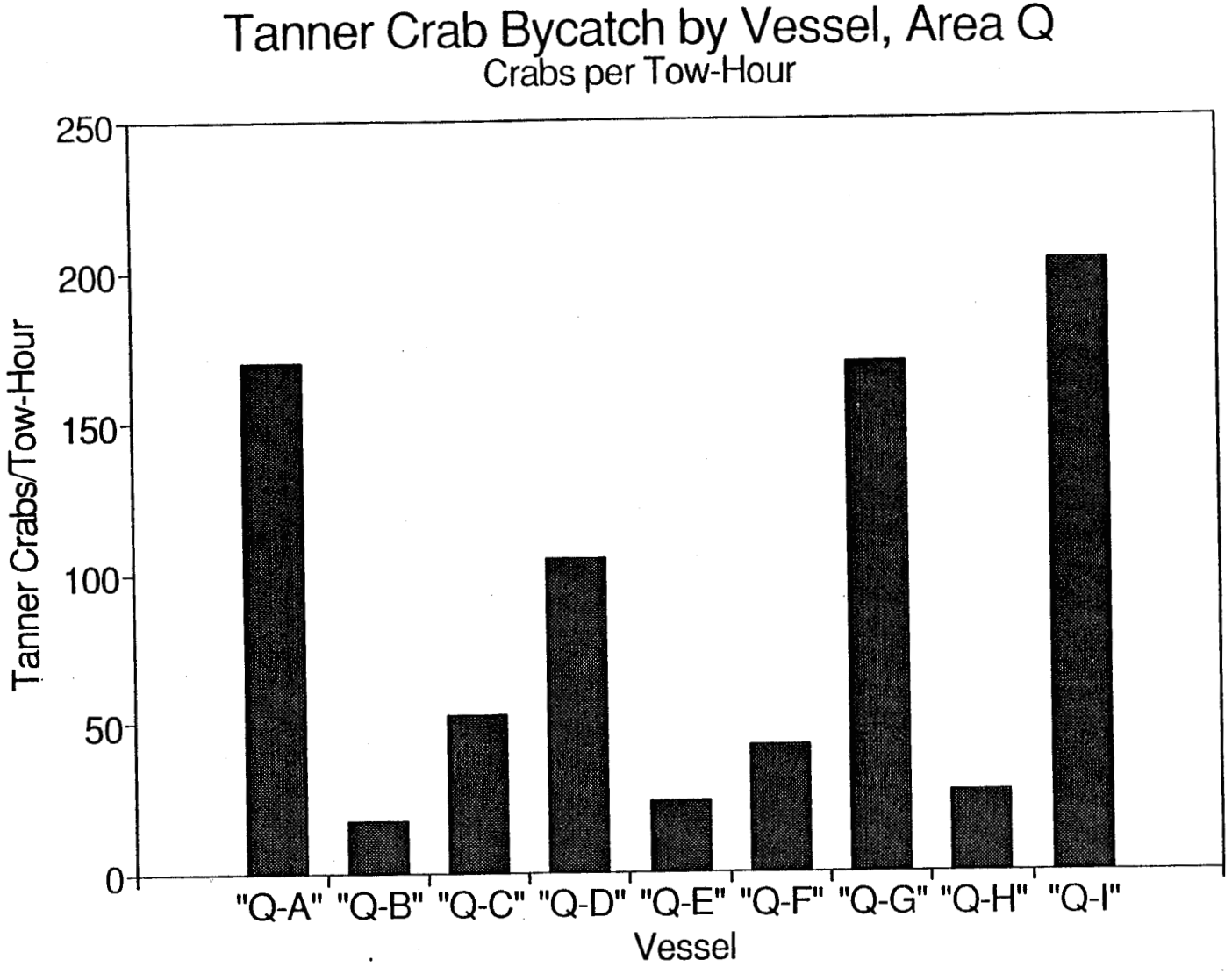


Figure 18. Number of Tanner crabs per round weight pounds of retained scallops in the bycatch of the nine vessels participating in the 1993 Bering Sea (Area Q) scallop fishery.

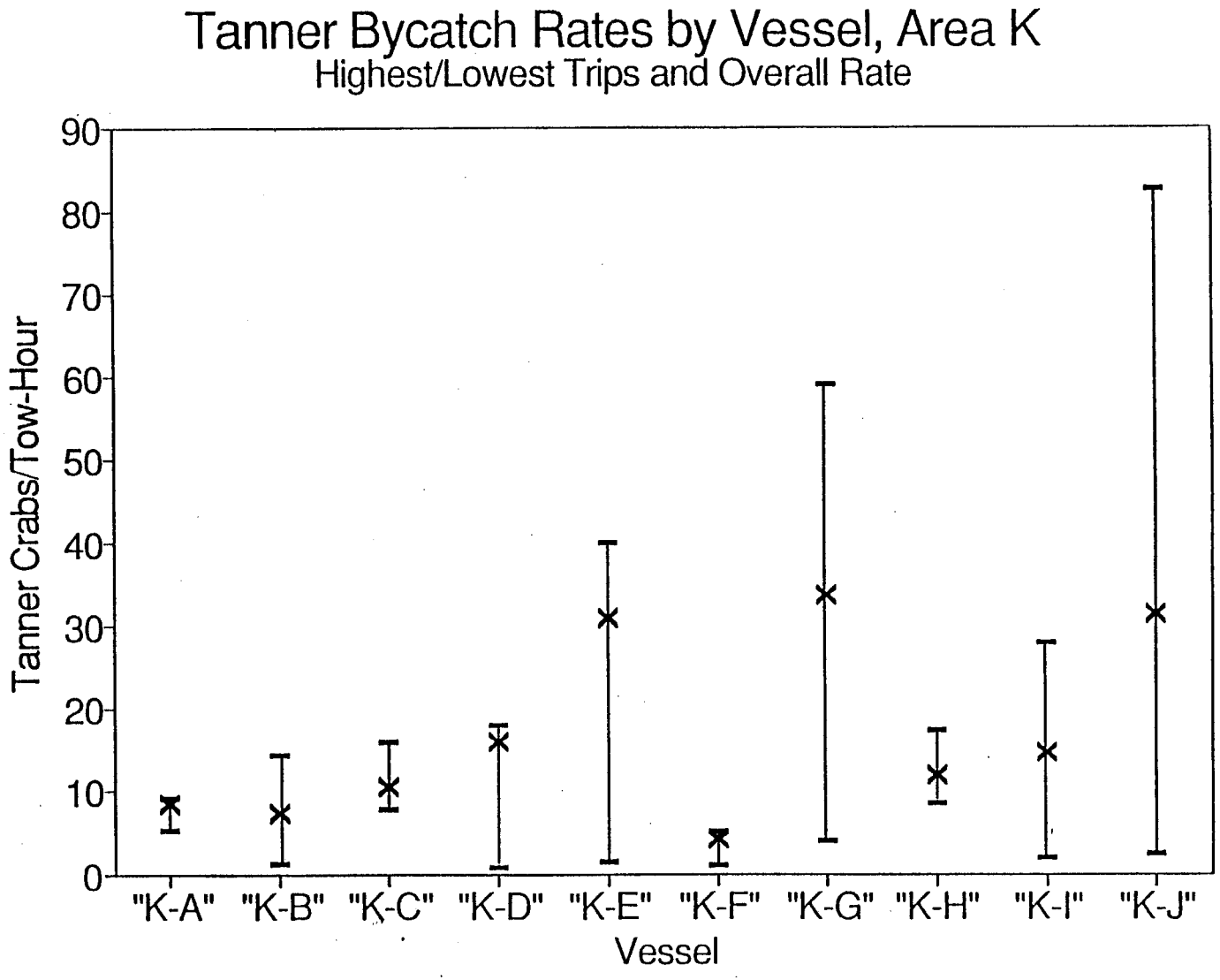


Figure 19. Number of Tanner crabs per tow-hour in the trips with highest and lowest bycatch rates for each of the ten vessels participating in the 1993 Kodiak (Area K) scallop fishery. "X" denotes overall Area K rate for vessel.

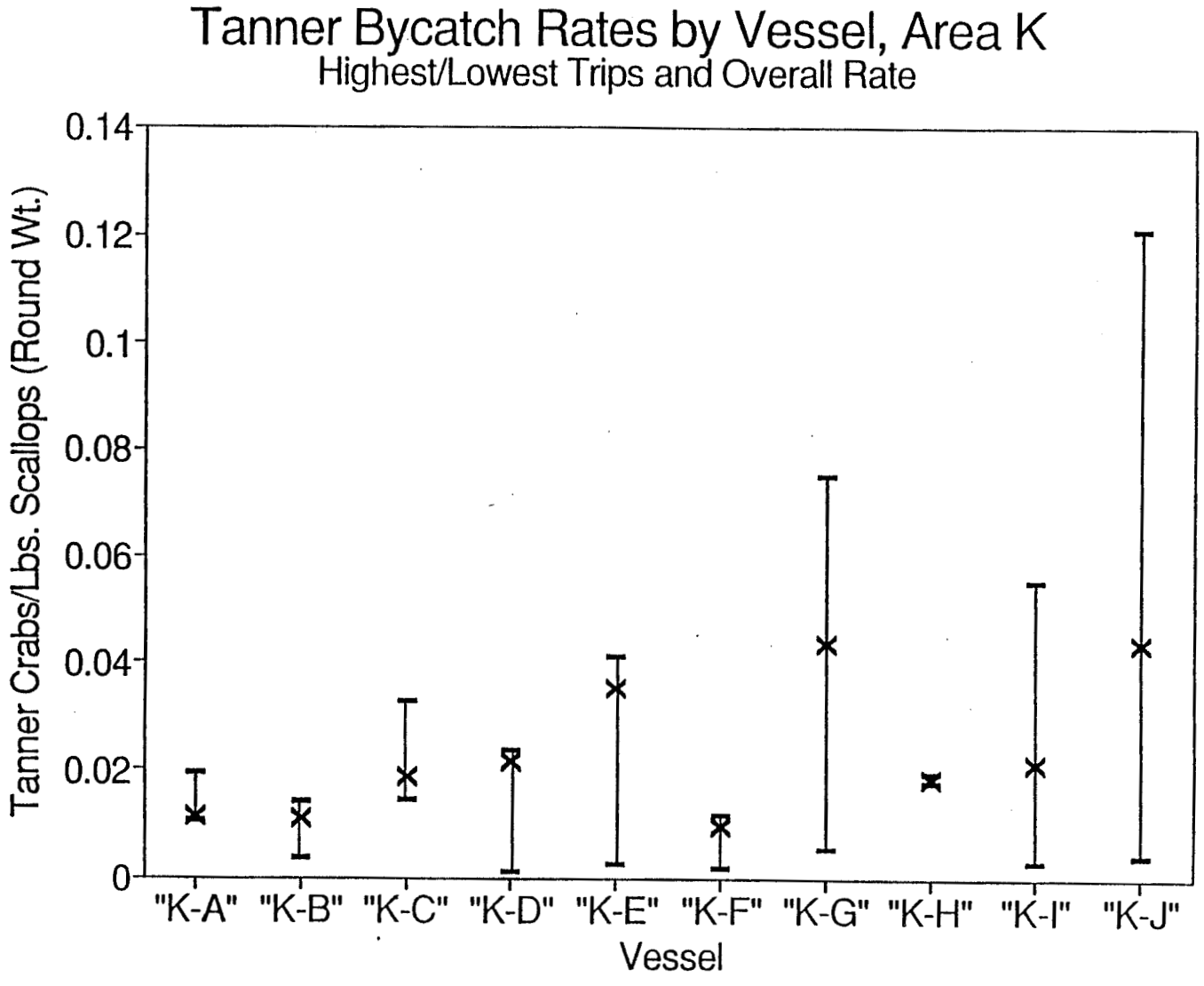


Figure 20. Number of Tanner crabs per round weight pounds of retained scallops in the trips with highest and lowest bycatch rates for each of the ten vessels participating in the 1993 Kodiak (Area K) scallop fishery. "X" denotes overall Area K rate for vessel.

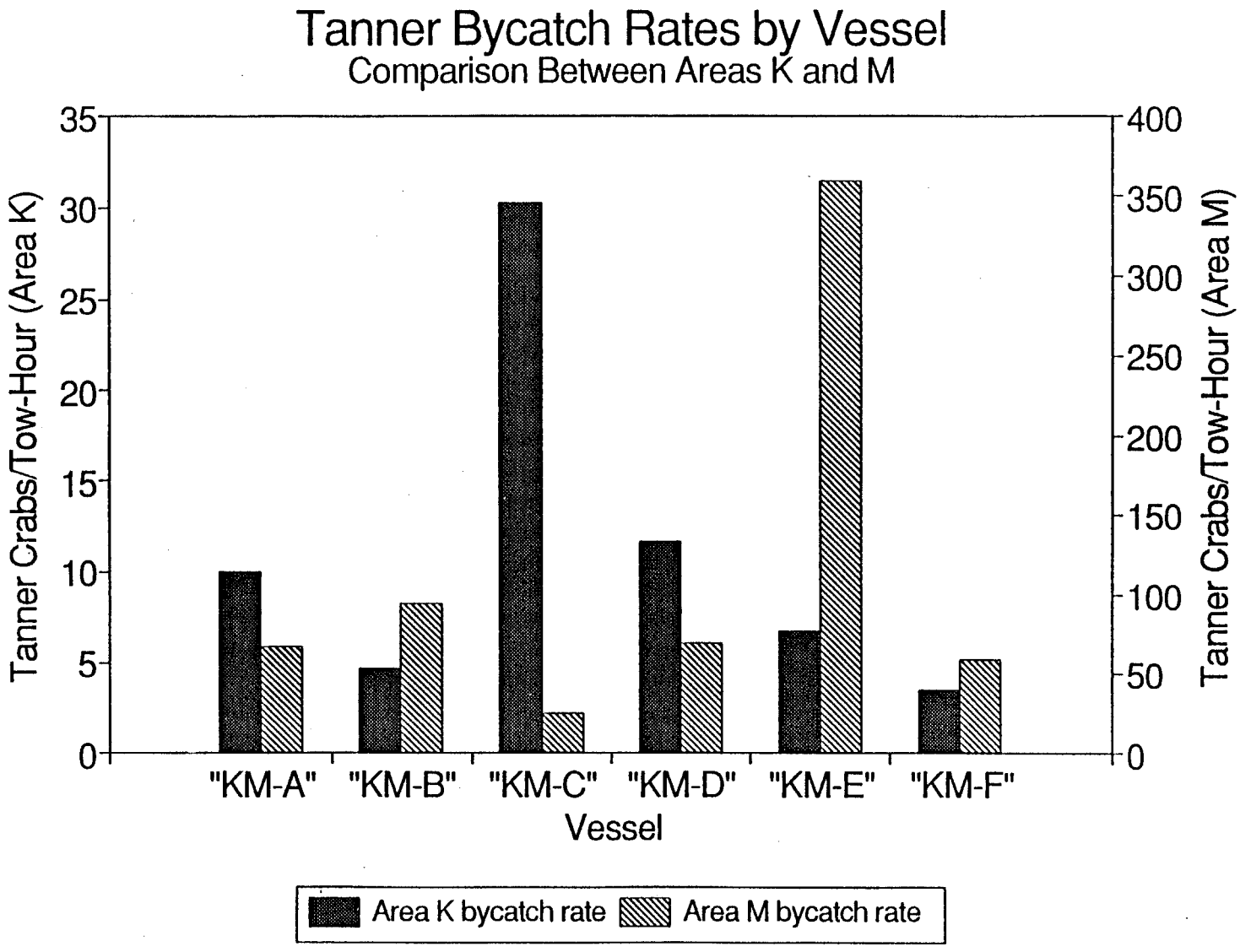


Figure 21. Comparison of number of Tanner crabs per tow-hour between the 1993 Kodiak (Area K) and 1993 Alaska Peninsula (Area M) scallop fisheries for each of six vessels that participated in both fisheries. Scale for bycatch rate (number/tow-hour) in Kodiak is on the left Y-axis, scale for the rate in the Alaska Peninsula is on the right Y-axis.

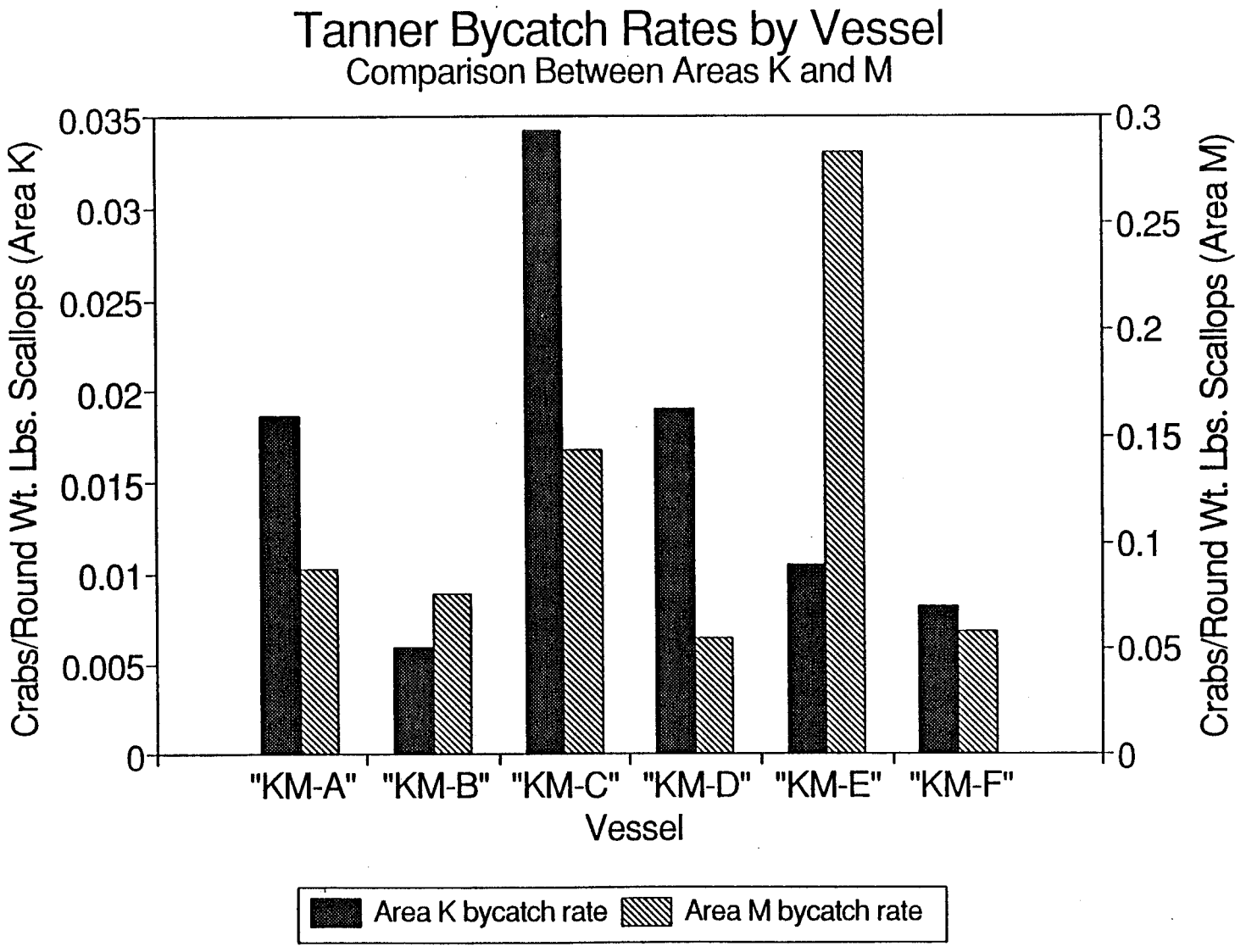


Figure 22. Comparison of number of Tanner crabs per round weight pounds of retained scallops between the 1993 Kodiak (Area K) and 1993 Alaska Peninsula (Area M) scallop fisheries for each of six vessels that participated in both fisheries. Scale for bycatch rate (number/lb) in Kodiak is on the left Y-axis, scale for the rate in the Alaska Peninsula is on the right Y-axis.

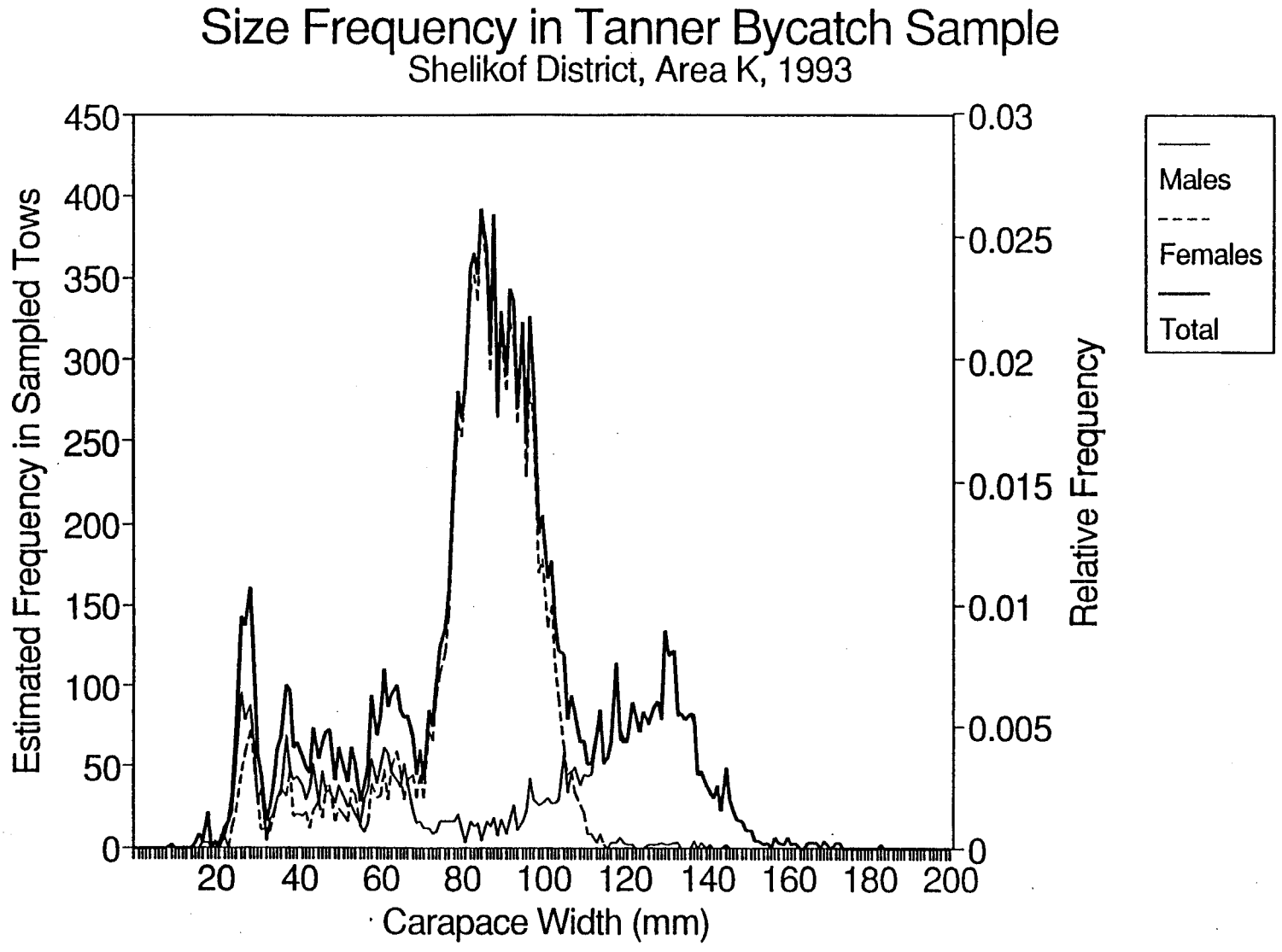


Figure 23. Carapace width (mm) size frequency of Tanner crabs in bycatch samples from the 1993 Shelikof District (Kodiak Area) scallop fishery. Size frequency is based on 10,321 measured crabs.

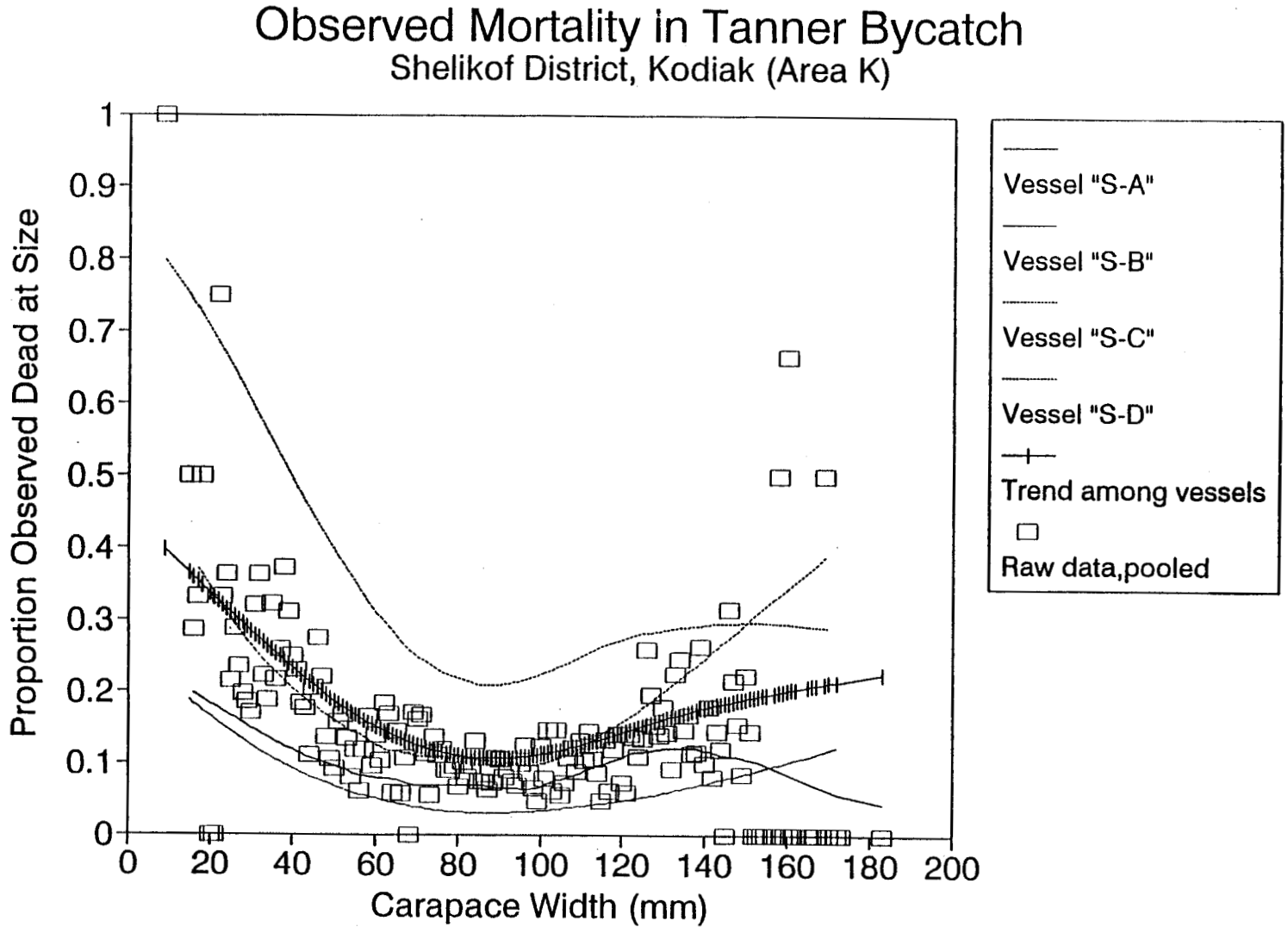


Figure 24. Observed-mortality rate in Tanner bycatch samples related to carapace width (mm) of crabs, 1993 Shelikof District (Kodiak Area) scallop fishery. Open squares denote the proportion of crabs observed dead at size in data pooled from all vessels. Curves without cross-hatching are local regression smoothings of the observed-mortality-at-size data from each vessel considered separately. The curve with cross-hatching is the overall estimate of the dependence of observed-mortality rate on size obtained from the trend among vessels without pooling the data from vessels and without weighting by the sample sizes for vessels.

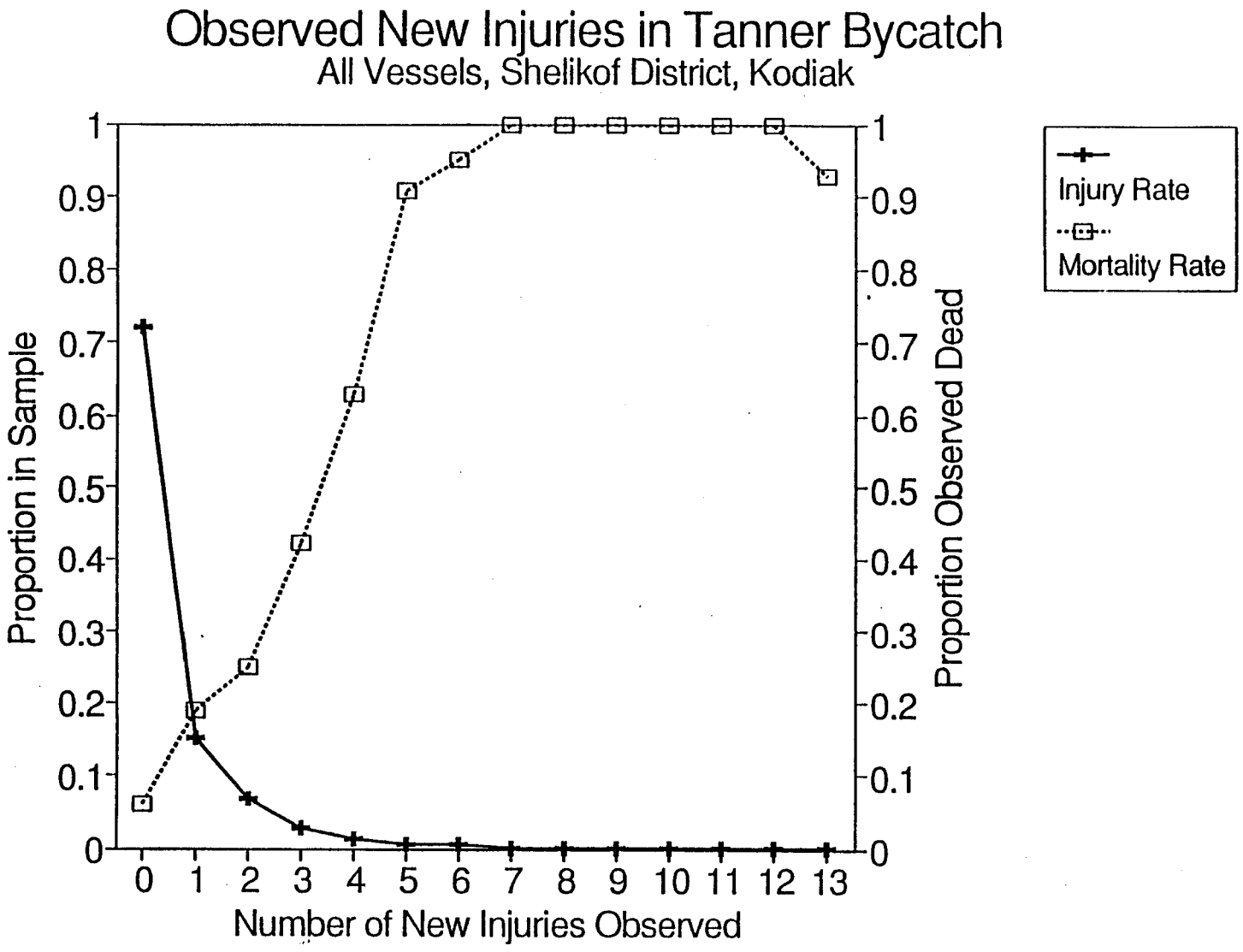


Figure 25. Incidence of number of new injuries (number of newly injured parts out of 13 inspected parts) and observed mortality rate for number of new injuries in Tanner bycatch samples, 1993 Shelikof District (Kodiak Area) scallop fishery. "+"'s and solid line denote the proportion of crab with specified number of new injuries and is scaled by the left y-axis. Open squares and dotted line denote the observed mortality rate for crabs with specified number of new injuries and is scaled by the right y-axis. See text for list of the 13 anatomical parts that were inspected for new injuries.

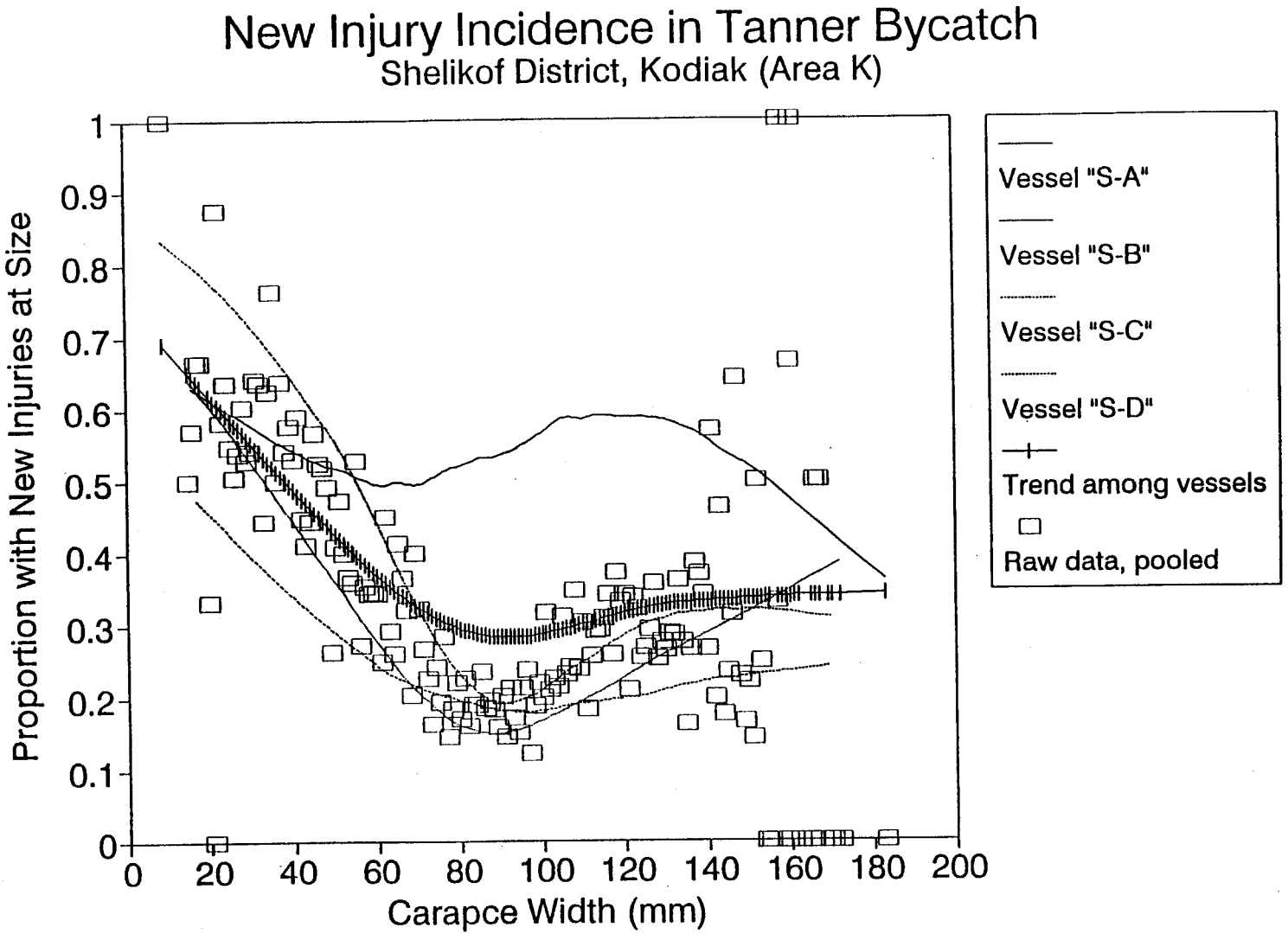


Figure 26. Proportion of crabs with new injuries in Tanner crab bycatch samples related to carapace width (mm) of crabs, 1993 Shelikof District (Kodiak Area) scallop fishery. Open squares denote the proportion of crabs at size with new injuries in data pooled from all vessels. Curves without cross-hatching are local regression smoothings of the new-injury-presence-at-size data from each vessel considered separately. The curve with cross-hatching is the overall estimate of the dependence of new-injury-presence rate on size obtained from the trend among vessels without pooling the data from vessels and without weighting by the sample sizes for vessels.

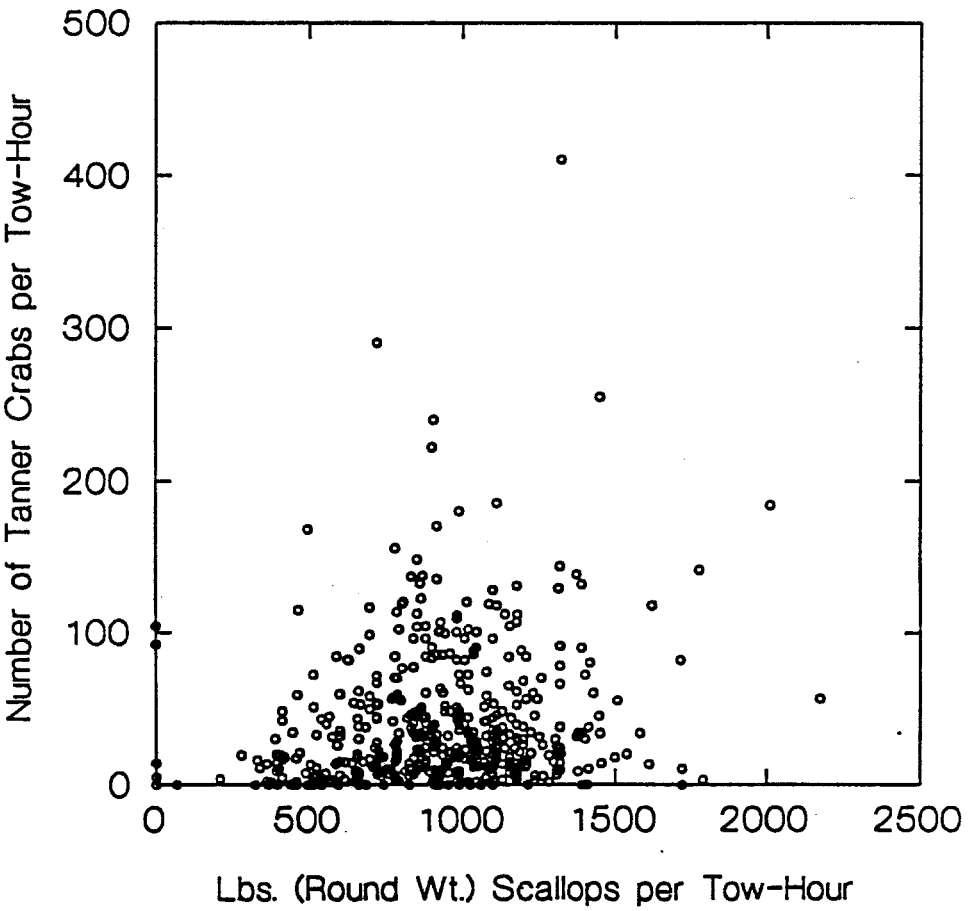


Figure 27. Comparison of Tanner crab bycatch rate (number of crabs per tow-hour) with scallop CPUE (round weight pounds of retained scallops per tow-hour) in individual tows sampled for bycatch, 1993 Shelikof District (Kodiak Area) scallop fishery.

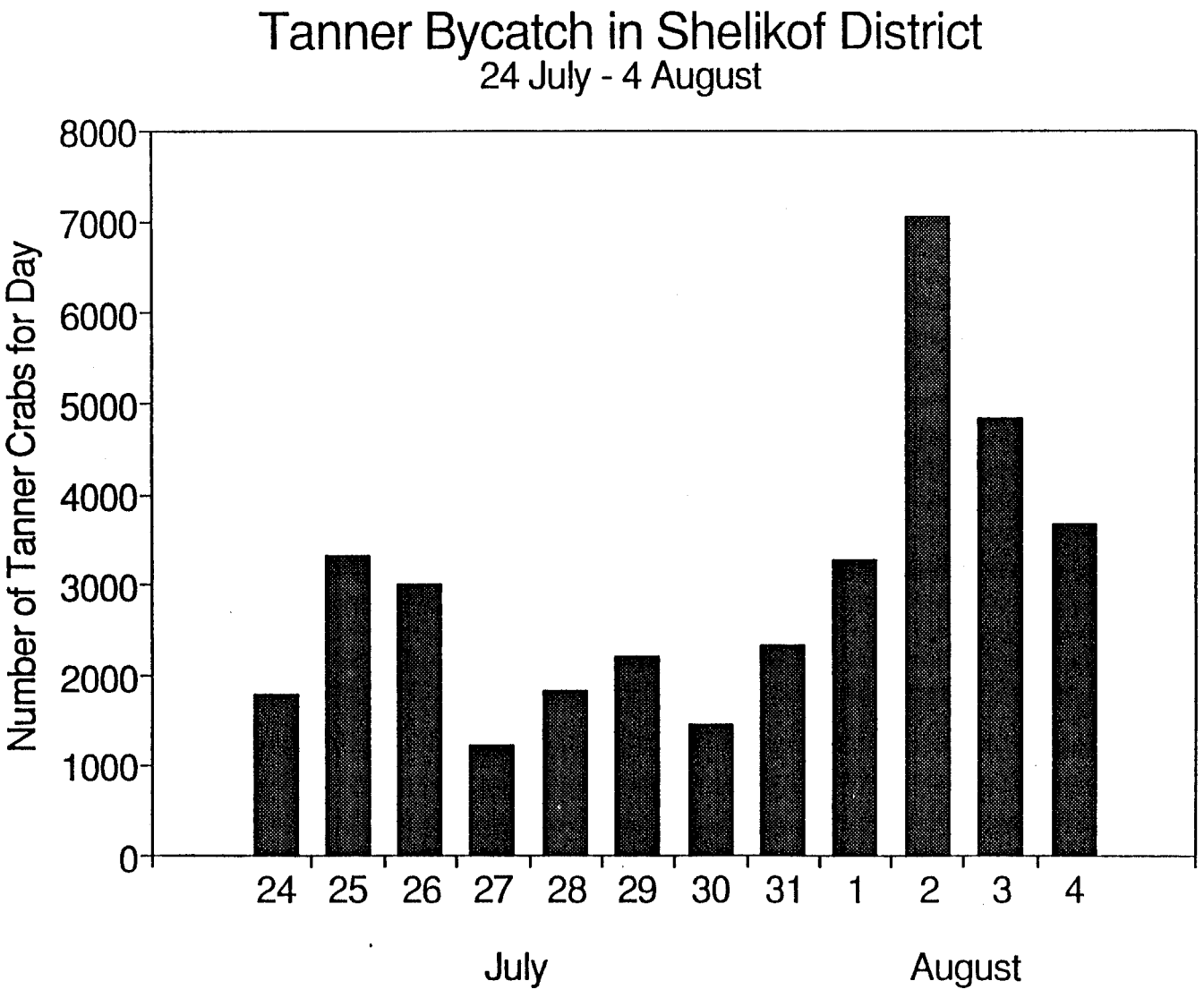


Figure 28. Estimated total daily bycatch of Tanner crabs in the 1993 Shelikof District (Kodiak Area) scallop fishery, July 24 through August 4.

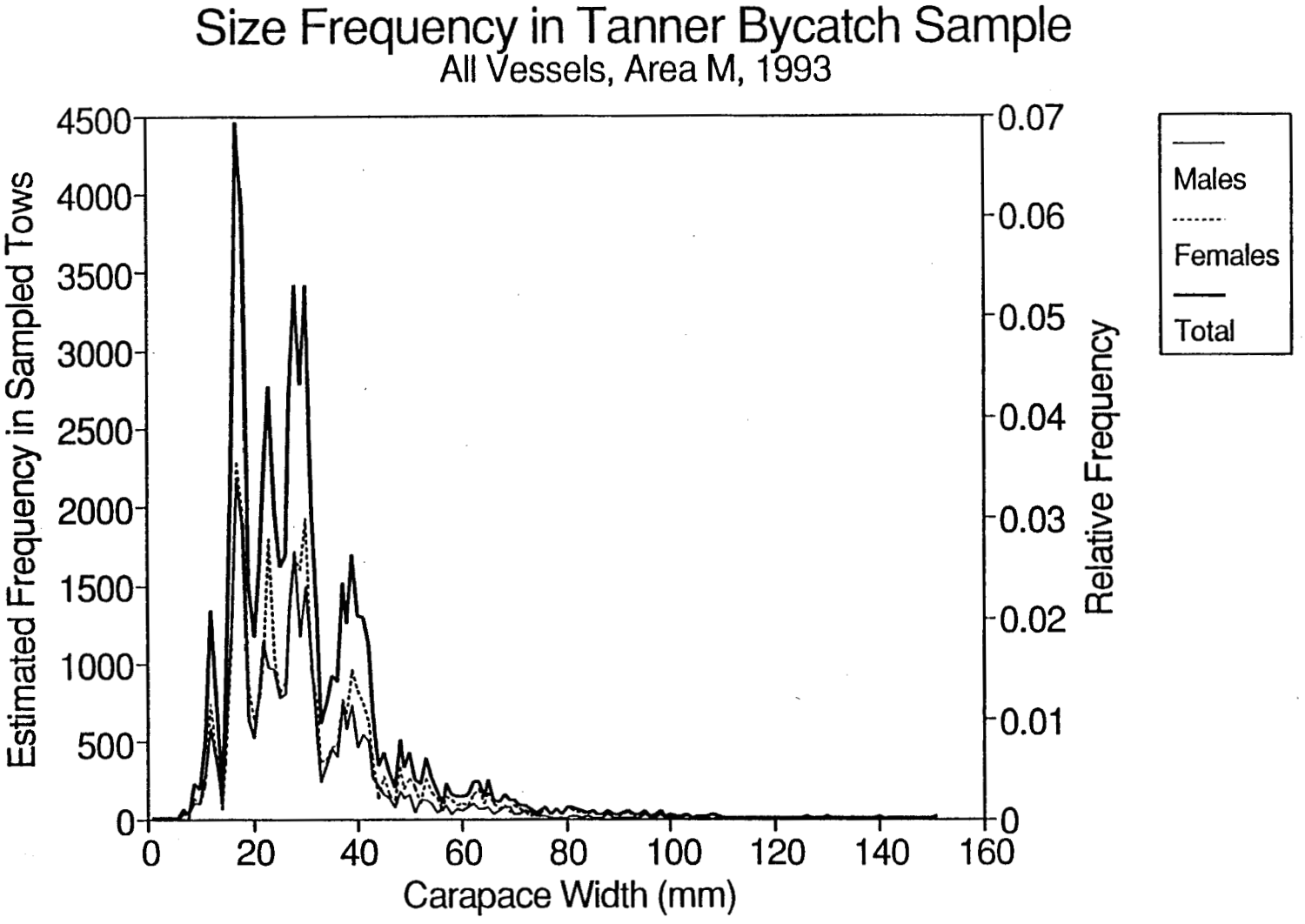


Figure 29. Carapace width (mm) size frequency of Tanner crabs in bycatch samples from the 1993 Alaska Peninsula scallop fishery. Size frequency is based on 10,466 measured crabs.

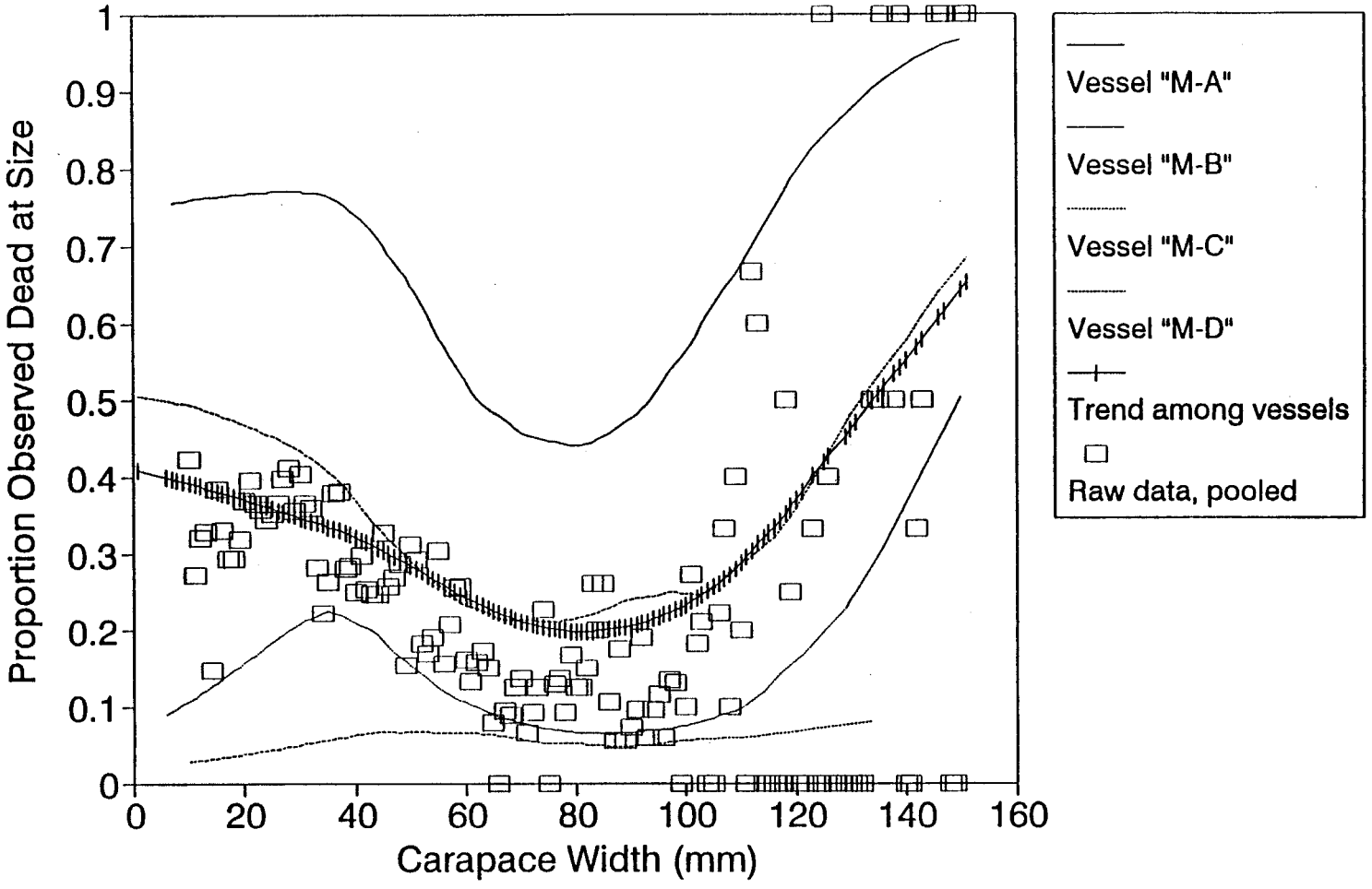


Figure 30. Observed-mortality rate in Tanner bycatch samples related to carapace width (mm) of crabs, 1993 Alaska Peninsula scallop fishery. Open squares denote the proportion of crabs observed dead at size in data pooled from all vessels. Curves without cross-hatching are local regression smoothings of the observed-mortality-at-size data from each vessel considered separately. The curve with cross-hatching is the overall estimate of the dependence of observed-mortality rate on size obtained from the trend among vessels without pooling the data from vessels and without weighting by the sample sizes for vessels.

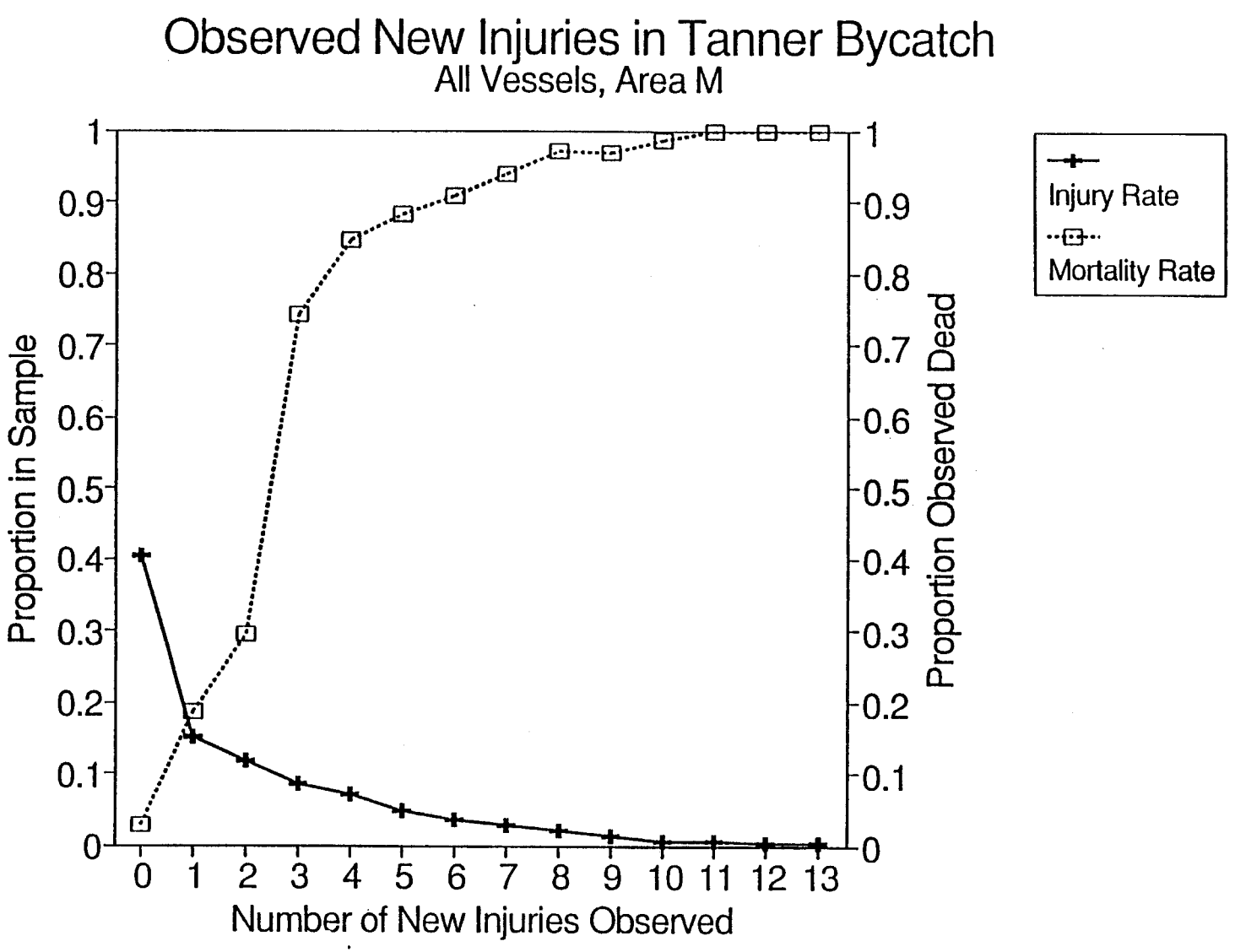


Figure 31. Incidence of number of new injuries (number of newly injured parts out of 13 inspected parts) and observed mortality rate for number of new injuries in Tanner bycatch samples, 1993 Alaska Peninsula scallop fishery. "+"'s and solid line denote the proportion of crab with specified number of new injuries and is scaled by the left y-axis. Open squares and dotted line denote the observed mortality rate for crabs with specified number of new injuries and is scaled by the right y-axis. See text for list of the 13 anatomical parts that were inspected for new injuries.

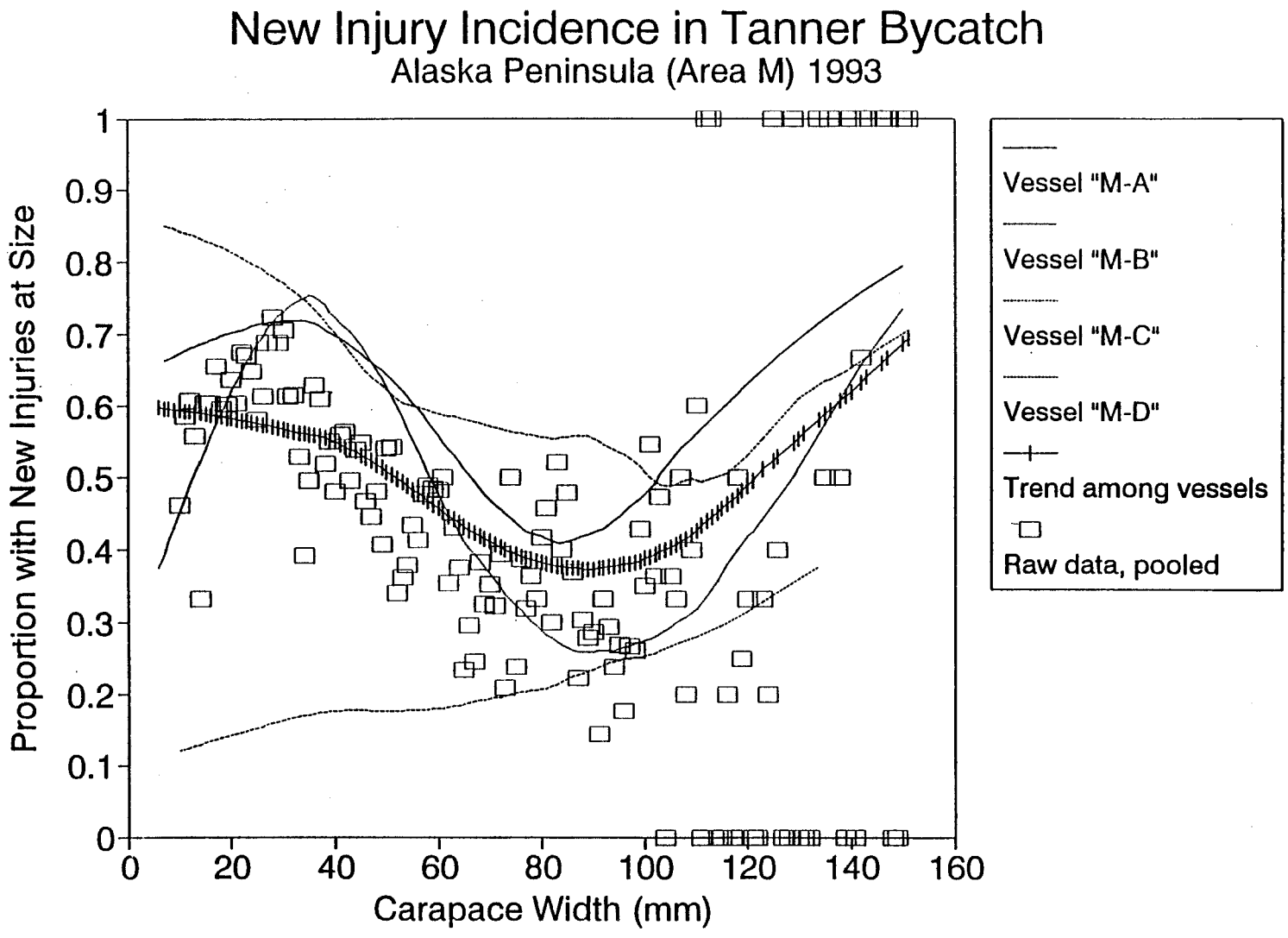


Figure 32. Proportion of crabs with new injuries in Tanner crab bycatch samples related to carapace width (mm) of crabs, 1993 Alaska Peninsula scallop fishery. Open squares denote the proportion of crabs at size with new injuries in data pooled from all vessels. Curves without cross-hatching are local regression smoothings of the new-injury-presence-at-size data from each vessel considered separately. The curve with cross-hatching is the overall estimate of the dependence of new-injury-presence rate on size obtained from the trend among vessels without pooling the data from vessels and without weighting by the sample sizes for vessels.

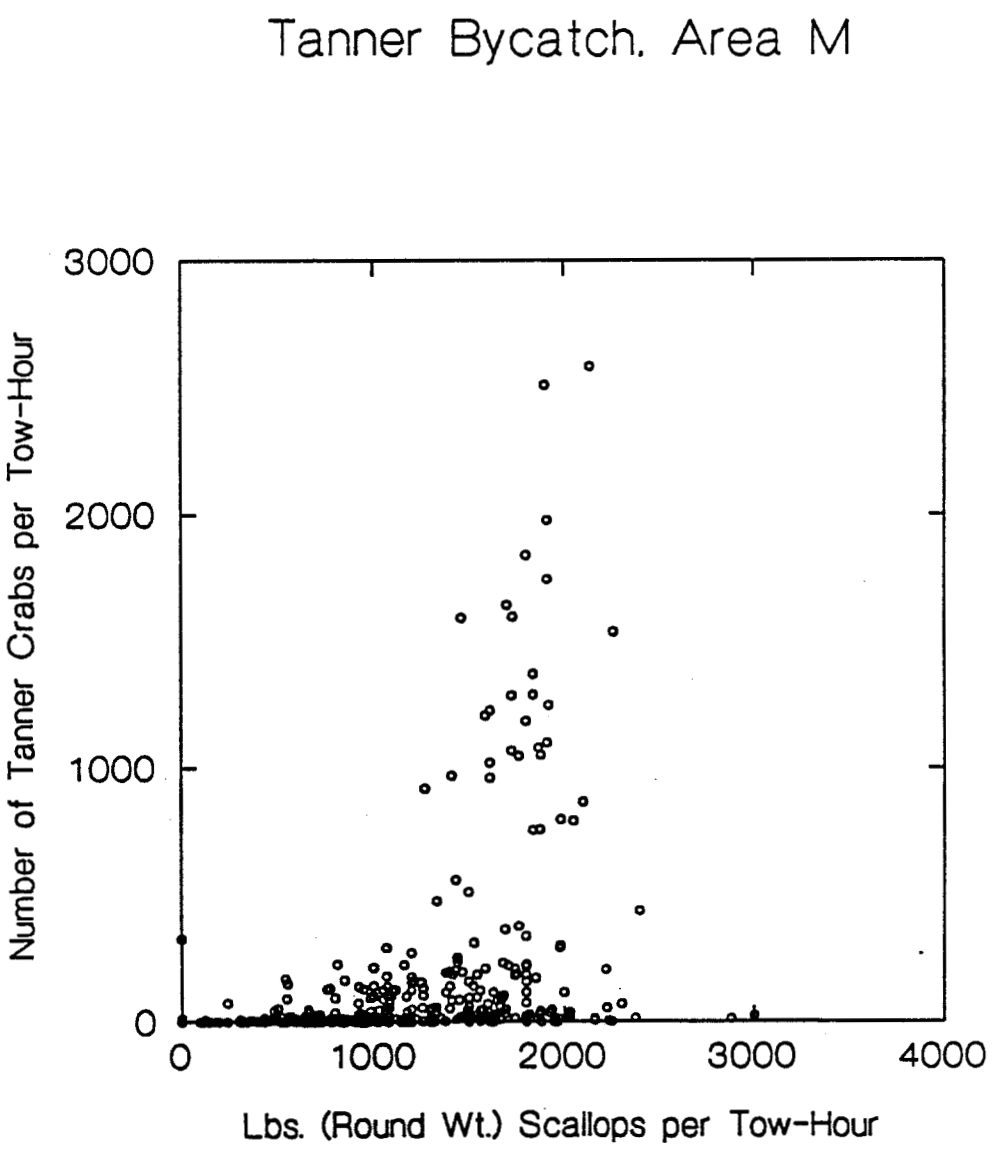


Figure 33. Comparison of Tanner crab bycatch rate (number of crabs per tow-hour) with scallop CPUE (round weight pounds of retained scallops per tow-hour) in individual tows sampled for bycatch, 1993 Alaska Peninsula scallop fishery.

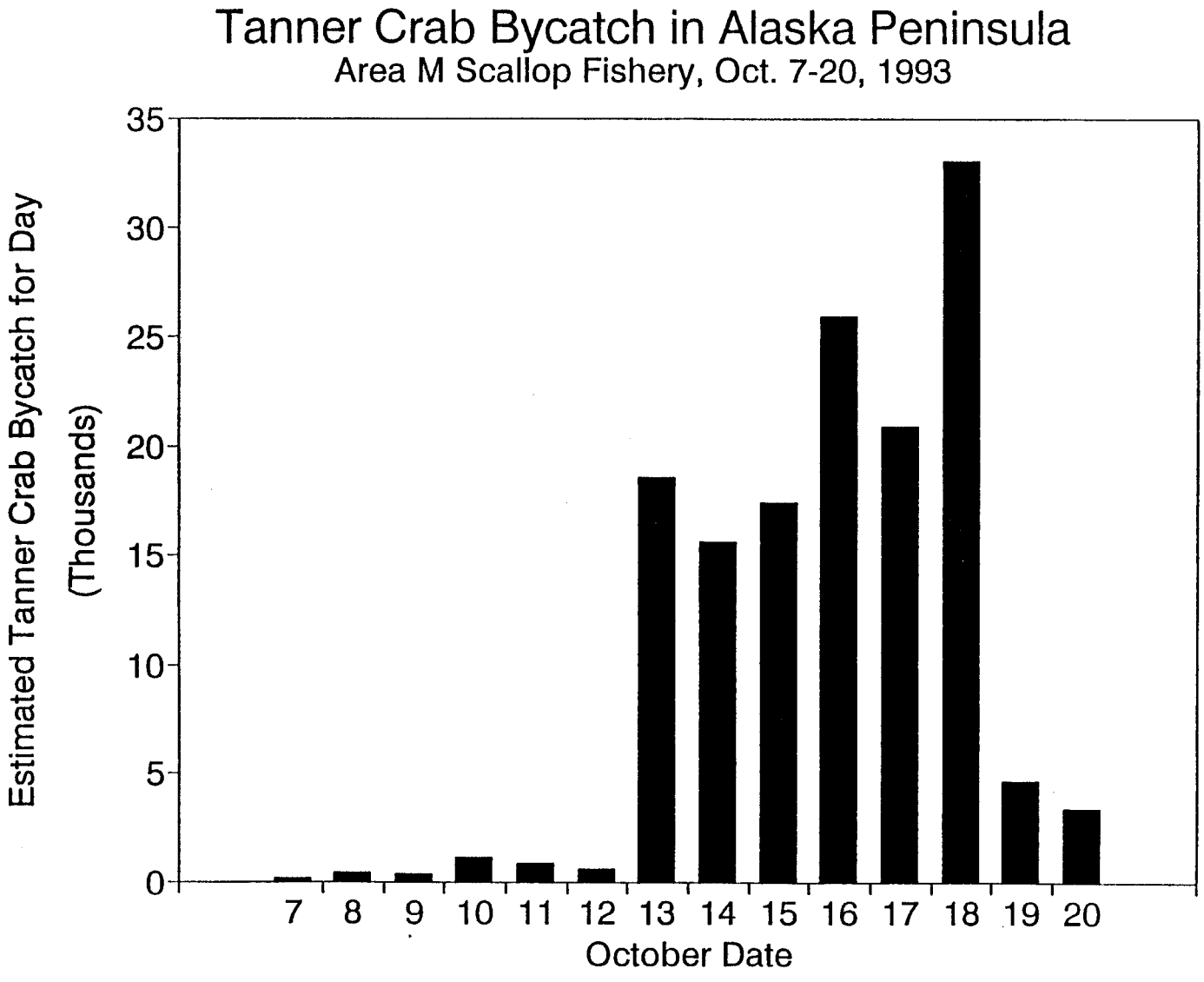


Figure 34. Estimated total daily bycatch of Tanner crabs in the 1993 Alaska Peninsula scallop fishery, October 7 through October 21.

APPENDIX

Appendix A. Haul form used by the mandatory scallop observers to record the species composition and monitor crab and halibut by-catch.

ALASKA DEPARTMENT OF FISH AND GAME
SCALLOP OBSERVER HAUL FORM

p _ of _

Trip #	ADF&G #	Haul #

Observer _____
Vessel _____
Date _____

☐ # of dredges sampled

☐ Sample type
1–crab/halibut monitoring
2–Species composition

SPECIES	SPECIES CODE	(6)wt. in subsamp.	(7)# in subsamp.	(8)number in total catch	(9)weight in total catch
Weathervane scallops	7 4 1 2 0				
Chlamys scallops	7 4 1 0 4				
Octopus	7 8 0 1 0				
Starfish	8 0 0 0 0				
Rock Sole	1 0 2 6 0				
Butter Sole	1 0 2 7 0				
Arrowtooth Flounder	1 0 1 1 0				
Flathead Sole	1 0 1 3 0				
Tanner Crab *C. bairdi*	6 8 5 6 0				
Red King crab	6 9 3 2 2				
Halibut	1 0 1 2 0				

Subsample calculations

(1) Estimated total catch–lbs. _____

(2) Fish, Rocks, etc. weighed directly– lbs. _____

(3) Wt. from which subsample is taken– lbs. (1 minus 2) _____

(4)Total subsample weight– lbs. _____
(sum of column 6)

(5) Raising Factor used to expand individual subsample weights to weight in total catch
(3 divided by 4) _____

(Weight in total catch = Species subsample weight multiplied by the raising factor)

Note: All crab and halibut will be measured and recorded on a separate form.

Appendix B. Crab size and injury form used by the mandatory scallop observers to record crab lengths and injuries from crab in sampled hauls.

ALASKA DEPARTMENT OF FISH AND GAME
CRAB SIZE AND INJURY FORM

p __ of __

Observer _____
Vessel _____
Date _____

Trip #	ADF&G #	Haul #

# of dredges sampled ☐

Spp. Code	Sex male=1 female=2	shell size (mm)	Shell Cond	Checked for injury y=1,n=2	Damaged Parts: Carapace	Abdomen	Rostrum	Left Chela	1st L. walking leg	2nd L. walking leg	3rd L. walking leg	4th L. walking leg	Right Chela	1st R. walking leg	2nd R. walking leg	3rd R. walking leg	4th R. walking leg	Mortality

Species Codes
2= Red King Crab
3= Blue King Crab
6= C. Bairdi
7= Copilio
9= Dungeness crab

Shell Condition
0– Soft
1– New
2– Old
3– Very old

Damaged Parts
1–Old injury
2– New injury
*leave blank if no injury

Mortality
1– Dead
2– Alive

NOTE: Measure length of king crab, measure width of other crab.

Appendix C. Fishing log filled out by vessel captain to record haul location and catch information from each haul.

ALASKA DEPARTMENT OF FISH AND GAME
FISHING LOG FOR ALASKA SCALLOPS

Trip number	ADF&G #	Year

Captain's name ______________

Observer name ______________

Vessel Name ______________

Haul sampled	Total dredge width	Gear performance	Date Mon.	Date Day	Haul No.	Set position: Latitude (N)	Set position: E W	Set position: Longitude	Fishing times in ALT: Dredge on bottom	Fishing times in ALT: Dredge off bottom	Fishing duration (minutes)	Average bottom depth (fms)	Average Speed in knots	Catch: round weight in pounds	Discarded catch: round weight in pounds	ADF&G statistical area
													.			
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Haul sampled
1- yes
2- no

gear performance
1-satisfactory (both dredges)
2-unsatisfactory (both dredges)
3-partially satisfactory (one dredge satisfactory and one dredge unsatisfactory)

Appendix D. Halibut length and condition form used by the mandatory scallop observers to record the lengths and condition of halibut in sampled hauls.

ALASKA DEPARTMENT OF FISH AND GAME
HALIBUT LENGTH AND CONDITION FORM

Observer _____
Vessel _____
Date _____

Trip #	ADF&G #

# of dredges sampled ☐

Haul Number	Fish Length (cm)	Checked for injury Y=1, N=2	Condition Code	Comments

Condition Codes

1. Excellent – – vigorous body movement before and after release; could close operculum tightly; minor external injuries, if any.
2. Good – – feeble body movements; could close operculum tightly; minor external injuries, if any.
3. Fair – – no body movement; could close operculum tightly; minor external injuries, if any.
4. Poor – – no body movement; could move operculum but not tightly; severe injuries (eg. bleeding).
5. Dead – – no body or opercular movement.

Appendix E. Scallop size frequency forms used by the mandatory scallop observers to record the lengths, age, and gonadal development of 100 scallops per day. The observers were requested to sample these 100 scallops from at least three different hauls.

ALASKA DEPARTMENT OF FISH AND GAME
SCALLOP SIZE FREQUENCY FORM

Observer _____
Vessel _____
Date _____

Trip #	ADF&G #	Haul #

Sample type ☐

	Shell height (mm)	Age	Sex	Gonad Develop.		Comments
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						

Sex
1 – Male
2 – Female

Gonad Development
1 – Immature or juvenile
2 – Full or ripe
3 – Empty or spawned out
4 – Initial recovery
5 – Filling

Sample type
1 – Unsorted catch
2 – Retained catch
3 – Discarded catch

Appendix F. Weekly summary form used by the mandatory scallop observers to summarize their daily data collections.

ALASKA DEPARTMENT OF FISH AND GAME

WEEKLY SUMMARY

SCALLOP CATCHER PROCESSOR

Beginning Monday _____ through Sunday_____

Observer _____

Vessel _____

Skipper _____

Trip Number	ADF&G #	Year

Date fished		Statistical Area	Pounds of meat	Number of hauls	Average depth (fms)	Est. Number King Crab	Est. Number Tanner Crab
Month	Day						

	Statistical Area	Pounds of meat	Number of hauls	Est. Number King Crab	Est. Number Tanner Crab
WEEKLY					
TRIP					
SUMMARY					
TOTALS					

Estimated Number of Crab

(1). # of crab observed

(2). # Hauls observed

(3). # Hauls completed

Est. No. Crab = (1)/(2) X (3)

Appendix G. Radio Report form used by the mandatory scallop observers assemble and encode the numbers needed to make radio reports to ADF&G offices.

VESSEL_____

OBSERVER_____

YAKATAT SCALLOP OBSERVER RADIO REPORT FORM

		MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY	WEEK TOTAL
DATE									
ITEM 1 Stat. Area	Actual								
	Code								
ITEM 2 Total number of tows	Actual								
	Code								
ITEM 3 Number of tows sampled	Actual								
	Code								
ITEM 4 Pounds of Scallops Retained	Actual								
	Code								
ITEM 5 Sampling Condition	Actual								
	Code								
ITEM 6 Total number of Tanner crab in sampled tows	Actual								
	Code								
ITEM 7 Number of sampled tows that caught Tanner crab	Actual								
	Code								

Appendix H.

EVIDENCE FOR RECAPTURE OF PREVIOUSLY DISCARD BYCATCH TANNER FROM TRENDS IN MORTALITY AND NEW INJURY DATA AND RECOVERY RATES OF DISCARDED SCALLOP SHELLS

By

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Commercial Fisheries Management and Development Division
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Kodiak, Alaska 99615

INTRODUCTION

On February 15, 1994 a summary of results from an early draft of Urban, et al. (1994) was presented orally by Westward Region ADF&G staff in Kodiak to the Kodiak Fish and Game Advisory Committee and scallop industry representatives. During presentation by staff of Tanner crab bycatch data on frequency of observed mortalities and new injuries in bycatch crab (see pp. 9-12 in Urban, et al., 1994) a scallop industry representative asked if the multiple injuries in bycatch crab and high observed-mortality rates reported for small crabs could be due to repeated captures of the same crabs by scallop dredges. That representative noted that scallopers repeatedly retow the same areas, making it possible for bycatch crabs to be caught, released, and recaptured; since the discarded shells from previously caught and shelled scallops do occur in heavily dredged locations (see p. 4 of Urban et al., 1994), recapture of previously discarded bycatch crabs may also occur. It was further noted that if, in fact, substantial recaptures of discarded bycatch does occur, total bycatch estimates would be biased high.

Westward staff conceded that the extent to which discarded bycatch is recaptured and the influence of recapture of total bycatch estimates are unknown. It was noted by Westward staff, however, that if recapture of bycatch was substantial, then we would expect to see increasing rates of both observed mortality and of incidence of new injuries in consecutive tows within an area due to the additional trauma to recaptured crabs and to recapture of previously injured or killed individuals[1]. Westward staff assured those present at the meeting that the Tanner bycatch data would be reexamined to determine if trends in mortality rate and number of newly injured parts are present that are consistent with presence of previously discarded crabs in the bycatch.

Since the February 15, 1993 Kodiak Fish and Game Advisory Committee meeting, data have been reexamined for indications of recaptures of previously discarded bycatch Tanner crab. The investigation was limited to Tanner bycatch in the Alaska Peninsula (Area M) fishery from October 13, 1993 through October 18, 1993, since this was a period of highest observed daily bycatch of Tanner crab; nearly 90% of the estimated 151 thousand Tanner crab that were estimated to have been caught in the July 25-October 21 fishery occurred during this period (see Figure 34 of Urban, et al., 1994). Additionally, the bycatch during this period was predominated by the small-sized (15-35 mm in carapace width) crabs in which observed-mortality and new-injury rates are highest (see Figures 24, 26, 30, and 32 of Urban, et al., 1994). Moreover, the geographic distribution of 335 scallop dredging tows performed by the four vessels participating during this period in Area M was extremely concentrated (Appendix H.1). In short, if evidence for recapture of bycatch Tanner crabs exists from increasing trends in the observed-mortality and number of newly injury parts, we would expect to see it in the data on 15-35 mm carapace width (cw) crab collected from the bycatch of the Area M during the period October 13-18, 1993. Bycatch data was also examined for any trends in mean size of the 15-35 mm cw bycatch Tanner crabs for comparison with the mortality and new injury trends.

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[1] Another representative of the scallop industry countered this remark by stating that mortality rates and incidence of new injuries may not increase due to new crabs being "chummed in" to dredged areas -- a statement that also indicates that the influence of previously discarded bycatch on the estimates of mortality rates, new injury rates, and total bycatch in negligible.

Even if evidence of mortality and new injuries trends exist in the Tanner bycatch data that are consistent with presence of recaptured discard, meaningful estimation of the proportion of the bycatch that was recaptured discard from the bycatch data alone is not possible; such estimation would require too much assumptions on models and model parameters for the bycatch data that cannot be defended with data. It is, however, possible to estimate the proportion of total scallop catch coming from previously discarded scallops by using the observer data on the round weight of retained scallops and the weight of empty scallop shells in the catch coupled with estimates from the literature of the ratio of whole scallop weight to shell weight. Recapture rates based on the recovery of discarded scallop shells may not be applicable to recapture rates of previously discarded Tanner crabs. Nonetheless, since recovery of empty scallop shells by scallop dredges has been cited as an indication of the potential for recapture of previously discarded bycatch, this estimate can serve as a baseline for discussion.

RESULTS

Trends in New Injuries

Average number of newly injured parts in sampled bycatch Tanner crab in the 15-35 mm cw size class during October 13-18, 1993 in Are M are plotted by consecutively sampled tow for each of the four participating vessels in Appendix H.2-H.5 (note that the randomly assigned letter designations used to identify the vessels are the same as were used in Urban, et al., 1994). The curve through the data points in each plot is a local regression smoother of the data, estimated under the assumption that number of newly injured parts in the bycatch crabs depends on consecutive tow number. Only in the data for tows 14 through 62 from vessel "M-C" (Appendix H.4) do we see any trend of increasing numbers of newly injured parts with consecutive tows, from an average of roughly 2.3 newly injured parts to 3.0 newly injured parts. Average number of newly injured parts in the bycatch Tanner crabs of vessel "M-B" (Appendix H.3) stays relatively flat at approximately 2 newly injured parts throughout the period, while the average for vessel "M-D" is generally below 1 newly injured parts throughout the period with only slight evidence if an increase after the 80th tow. Contrary to the trend that we are looking for, the number of newly injured parts in the Tanner crabs bycatch of vessel "M-A" tends to decrease through the later part of the period.

Trends in Observed Mortalities

Observed mortality rates in sampled bycatch Tanner crab in the 15-35 mm cw size class during October 13-18, 1993 in Area M are plotted by consecutively sampled tow for each of the four participating vessels in Appendix H.6-H.9. Again, the curve through the data points in each plot is a local regression smoother of the data, estimated under the assumption that binomial observed mortality data for the bycatch crabs depends on consecutive tow number. As with the injury data, it is only in the data for tows 14 through 62 from vessel "M-C" (Appendix H.8) that we see any trend of increasing observed-mortality rate with consecutive tows, from a rate of roughly 0.41 to 0.56; note, however, that observed-mortality rate decreases from roughly 0.50 to 0.41 prior to tow 14. Observed-mortality rate in the Tanner bycatch of vessel "M-B" stays relatively flat throughout the period at approximately 0.2, while that for the bycatch of vessel "M-D" is

generally below 0.1 with only slight evidence of an increasing rate after the 80th tow. Although showing an initial increase in observed-mortality rate from roughly 0.63 to 0.86 from tows 1 through 25, the data from vessel "M-A" again shows a trend contrary to what we are looking for by showing a subsequent decreasing trend in observed-mortality in the later part of the period (from roughly 0.86 to 0.69 after the 25th tow).

Trends in Size

Appendix H.10-H.13 are plots of the average cw of bycatch crabs in the 15-35 mm cw size class by consecutive tow for each of the four vessels. The curve in each plot is the local regression smoother of the size data, estimated under the assumption that average size is dependent on consecutive tow number. Average size does tend to change slightly with consecutive tow number in each of the vessels, with periods of both increasing and decreasing average size occurring throughout the October 13-18 period for each vessel. Though changes in average size that occur through the report period appear slight, we must recall that we are limiting our investigation to crabs from a very limited range of sizes, 15-35 mm cw.

It is notable that for the two cases (vessels "M-A" and "M-C") in which any trends exist in observed-mortality rate and average number of newly injured parts, average size by consecutive tow show an opposite trend; increases in observed-mortality rate and average number of newly injured parts coincide with decreases in average size, while decreases in observed-mortality rate and average number of newly injured parts coincide with increases in average size (compare Appendix H.2 and H.6 with Appendix H.10 and compare Appendix H.4 and H.8 with Appendix H.12). A negative relationship between size and both of observed-mortality rate and incidence of new injuries in small-sized bycatch Tanner crab was noted by Urban, et al. (1994, Figures 24, 26, 80, and 32). Thus, although an increasing trend in observed mortality and number of newly injured parts may be evidence of recapture of previously discarded crabs, in the one case where we saw such trends (vessel "M-C" dependency of observed-mortality and new-injury rates on size provides an alternative explanation for the trends.

Recovery of Discarded Scallops

Catch-composition samples from the statewide 1993 scallop observer data indicated that whole weathervane scallops constituted 80.2% of the total weight of the catch in scallop dredges throughout the observed 1993 scallop fishery, while empty weathervane scallop shells made up 6.5% of the total catch weight (Urban, et al., 1994, Table 3). Estimates of the ratio of whole weight to shell weight for samples of weathervane scallops range from 1.0:0.57 to 1.0:0.47 (State Government of Alaska, et al., 1989). Using these data, we can estimate the percent of recaptured previously discarded scallops (represented by empty shells) in the total (i.e., both newly captured whole scallops and the recaptures represented by empty shells) catch by,

$$\%Recaptures = \frac{P_S(W:S)}{P_S(W:S) + P_W}$$

where,

(W:S) is the ratio of whole weight to shell weight,
P_S is the percentage of empty shells in the catch (6.5%), and
P_W is the percentage of whole scallops in the catch (80.2%).

Using values of (W:S) ranging from 1/0.57 to 1/0.47 gives estimates of the percentage of recaptures in the statewide total scallop catch ranging from 12% to 15%.

SUMMARY

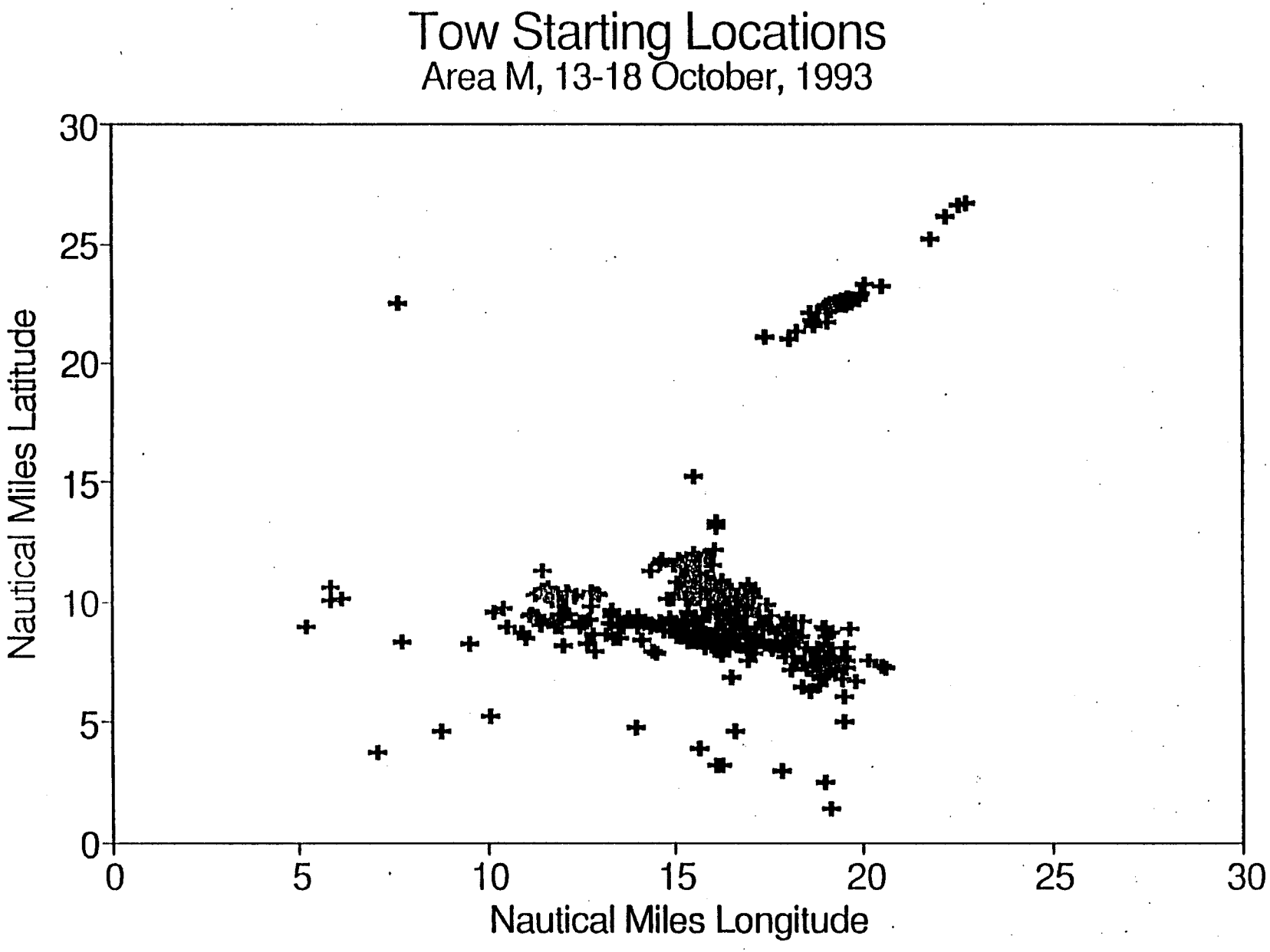
Out of the bycatch data on 15-35 mm cw Tanner crabs from four vessels participating in the Area M fishery during the period October 13-18, we saw clear increasing trends in observed-mortality rate and average number of newly injured parts over the later part of October 13-18 period in only one vessel. We also saw periods of decreasing trends in observed-mortality rate and number of newly injured parts in the data from two vessels; in one case, the period of decreasing trends occurred over the later part of the October 13-18 period. If an increasing trend in observed mortality and injury is considered to be evidence for recapture of previously discarded crabs, it becomes difficult to explain the observed periods of decreasing trends. When trends in observed mortality and new injuries existed, coincident trends in average size of the 15-35 mm cw Tanner bycatch were also apparent. Hence, the trends in observed-mortality rate and average number of newly injured parts may be attributable to changes in the average size of the bycatch crab, rather than to recapture of previously discarded crabs. Overall, we see little evidence for increased mortality or increases in number of newly injured parts in the data that is consistent with the presence of previously discarded crab in the bycatch. Additionally, recent analyses of data on numbers of new injuries in the Area M Tanner bycatch (not presented in Urban, et al., 1994) reveals that it is the larger (<120 mm cw) bycatch crabs that have the greatest numbers of newly injured parts; since large crabs occur so rarely in the bycatch (only 18 out of the 11,319 bycatch Tanner crabs sampled from Area M had cw > 120 mm), it does not seem likely that their injuries were due to multiple recaptures.

We estimated that 12%-15% of the total (i.e., either alive and whole or shelled and previously discarded) scallops had been recaptured as shells. This rate of recaptures in the total scallop catch can serve as a baseline for conjecture of what the rate of recapture of discarded bycatch is. It seems reasonable to assume that the recapture rates of discarded crabs will be lower than the 12-15% rate estimated for discarded scallop shells due to the greater potential of crabs to drift and be consumed by predators in the water column after discarding.

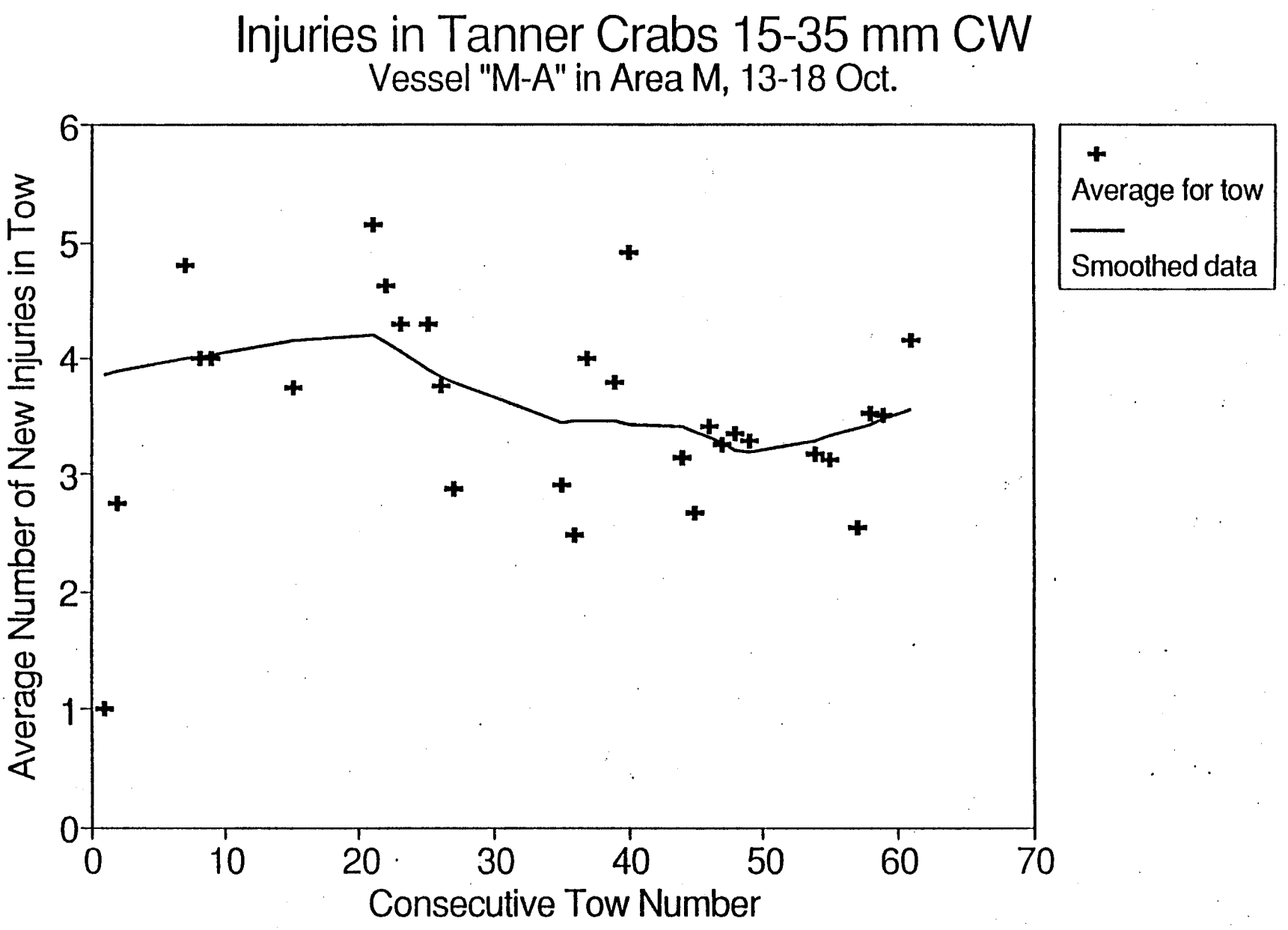
LITERATURE CITED

Urban, D., D. Pengilly, and I. Vining. 1994. The scallop observer program and statewide data analysis summary to the Board of Fisheries. Report presented to the Alaska Board of Fisheries, 14-16 March 1994, Anchorage, Alaska. Regional Information Report 4K94-??, Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Kodiak.

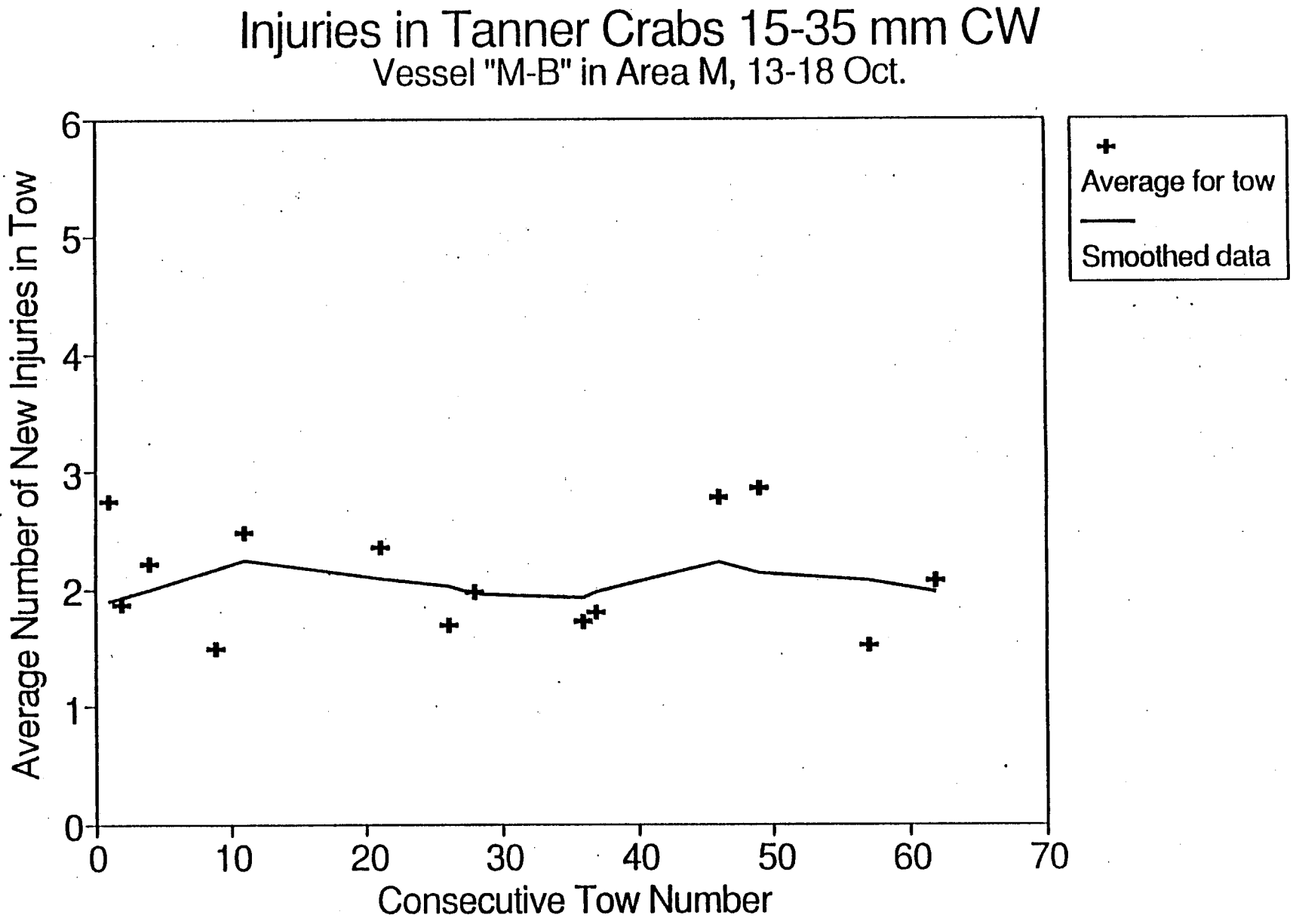
State Government of Alaska, Kodiak Area Native Association, Overseas Fishery Cooperative Foundation of Japan. 1989. Final report of the scallop mariculture feasibility study, Kodiak Island, Alaska, 1987 to 1988.



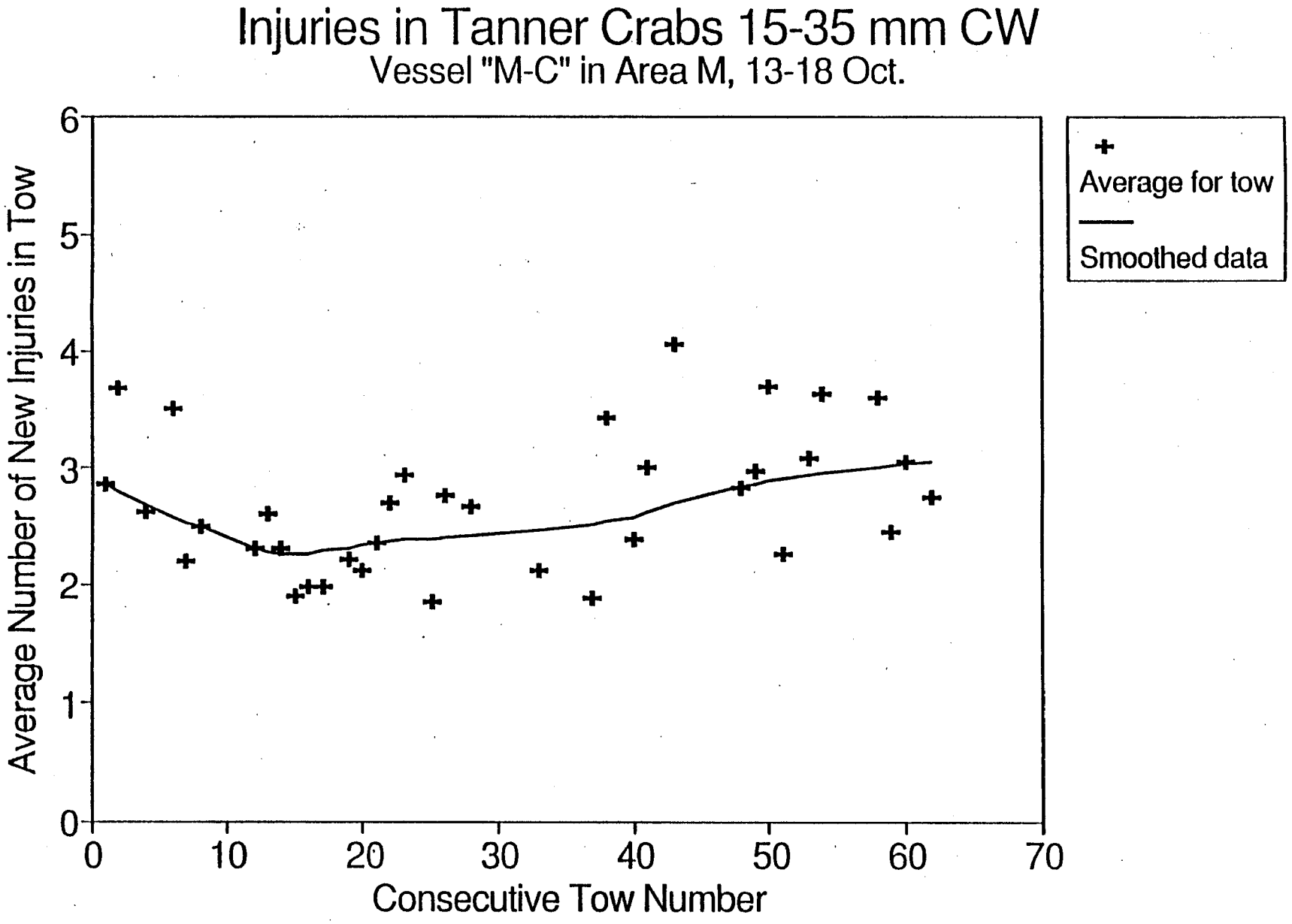
Appendix H.1. Starting locations of 335 tows performed by four scallop-dredging vessels in Area M, October 13-18, 1993. Scale is in nautical miles relative to an arbitrary origin.



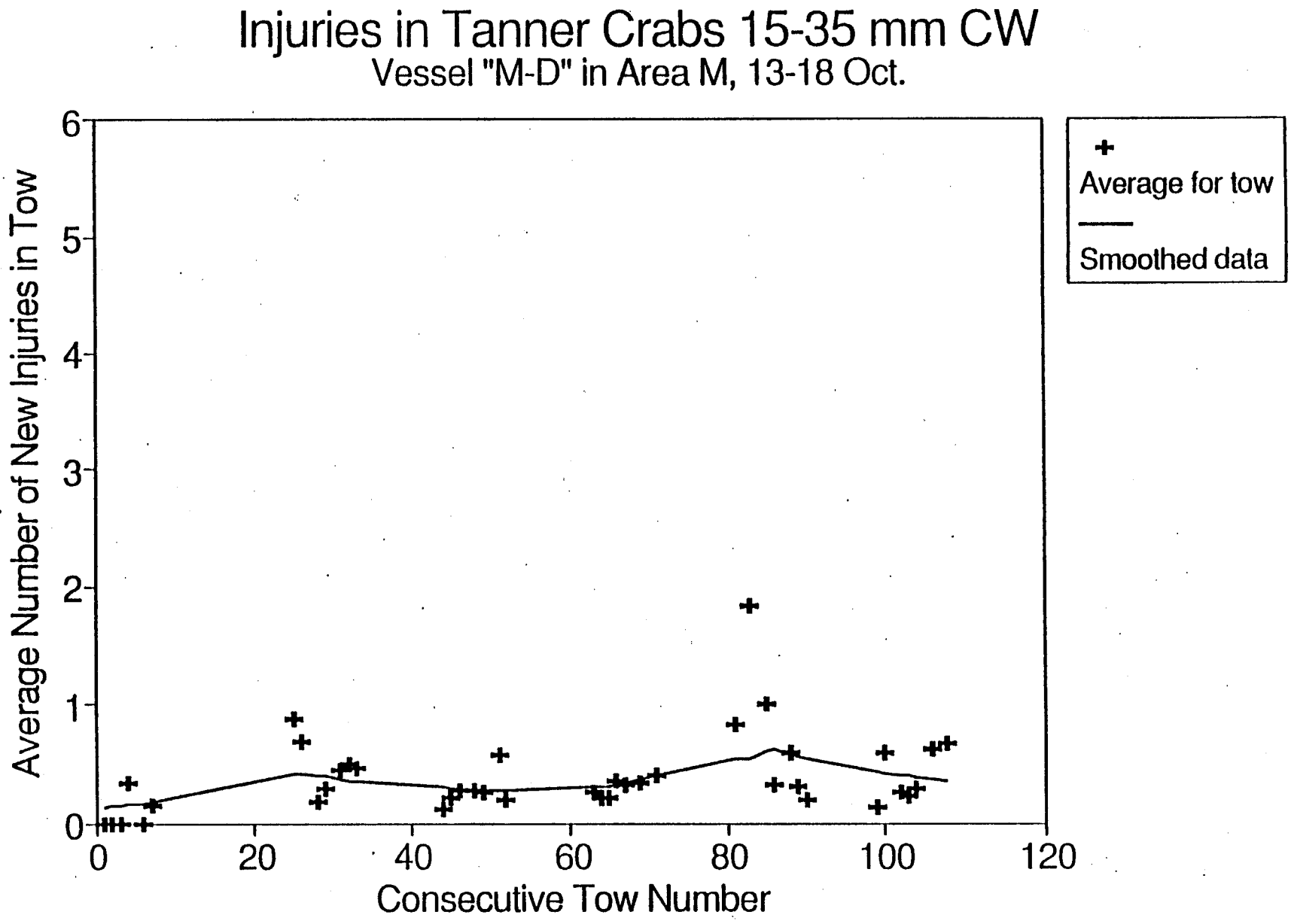
Appendix H.2. Average number of newly injured parts for sampling Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-A", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.



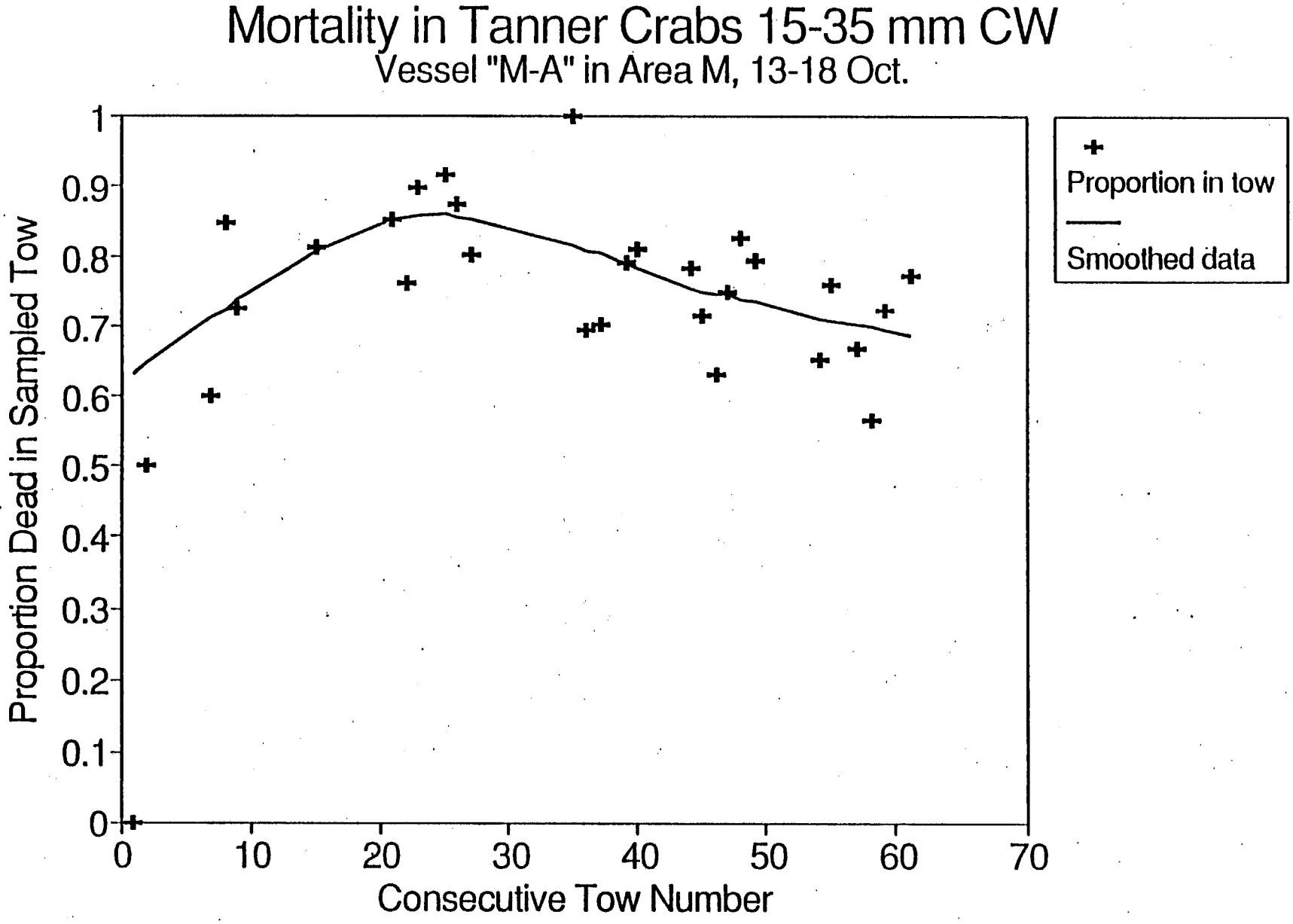
Appendix H.3. Average number of newly injured parts for sampled Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-B", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.



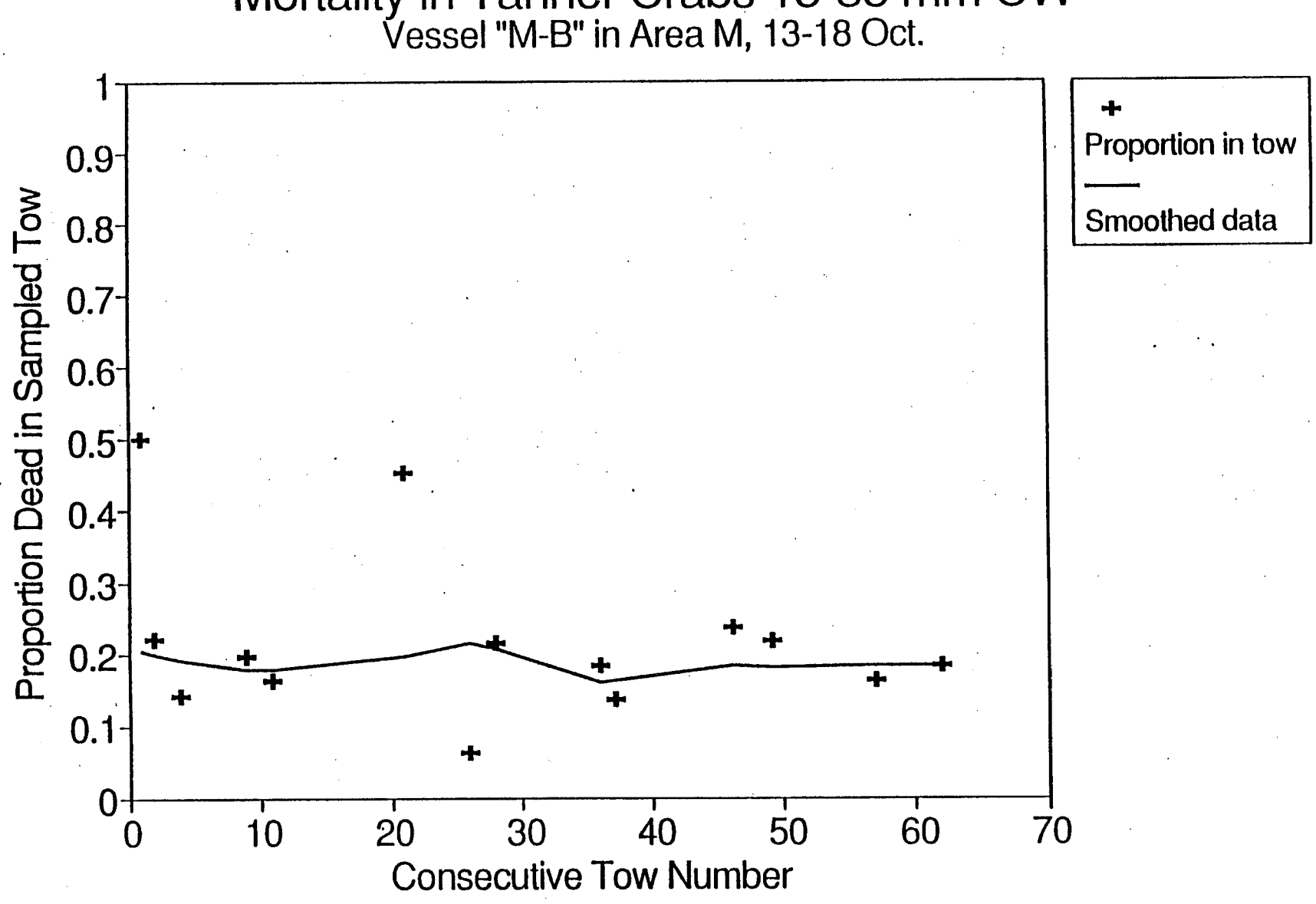
Appendix H.4. Average number of newly injured parts for sampled Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-C", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.



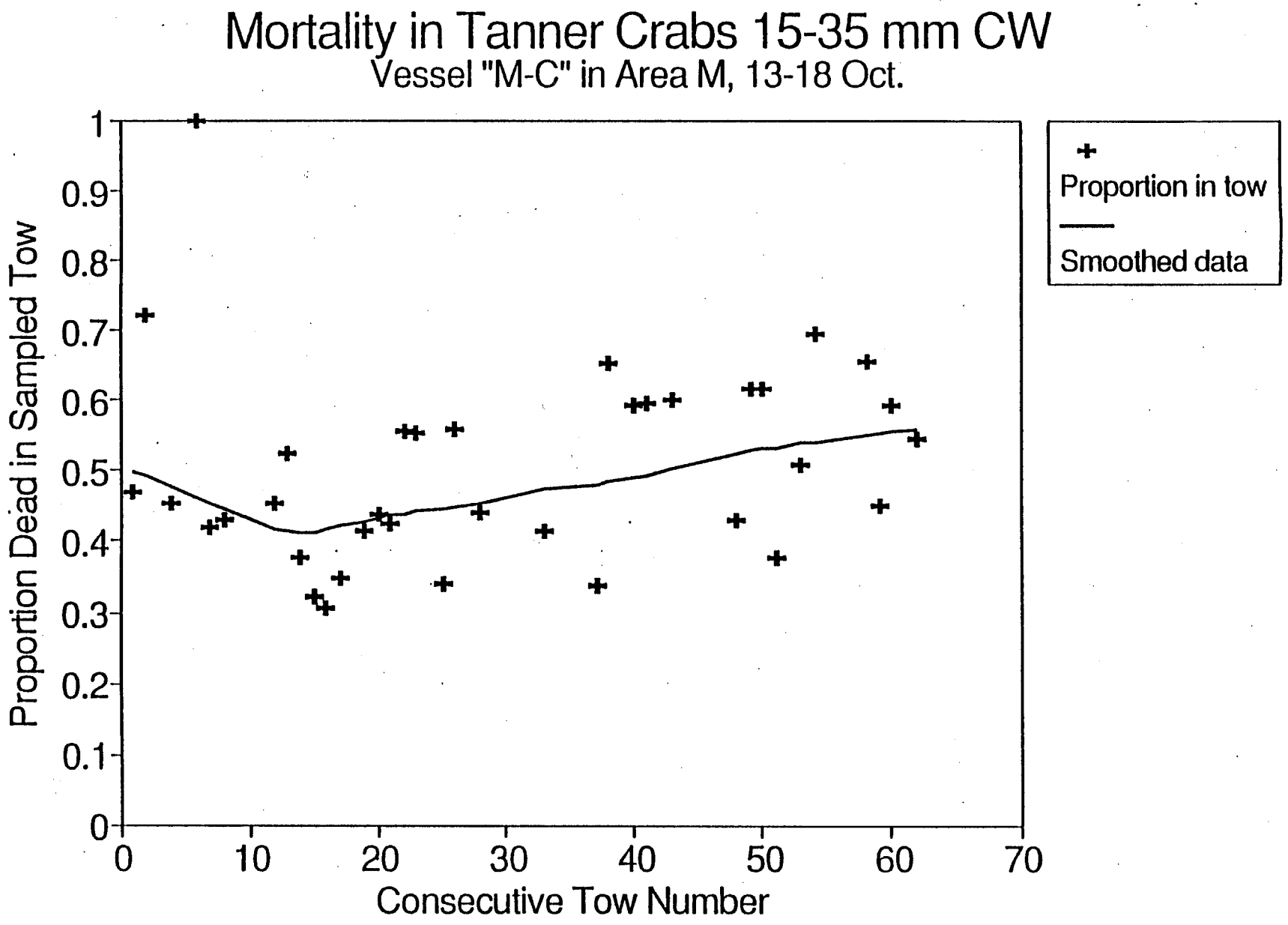
Appendix H.5. Average number of newly injured parts for sampled Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-D", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.



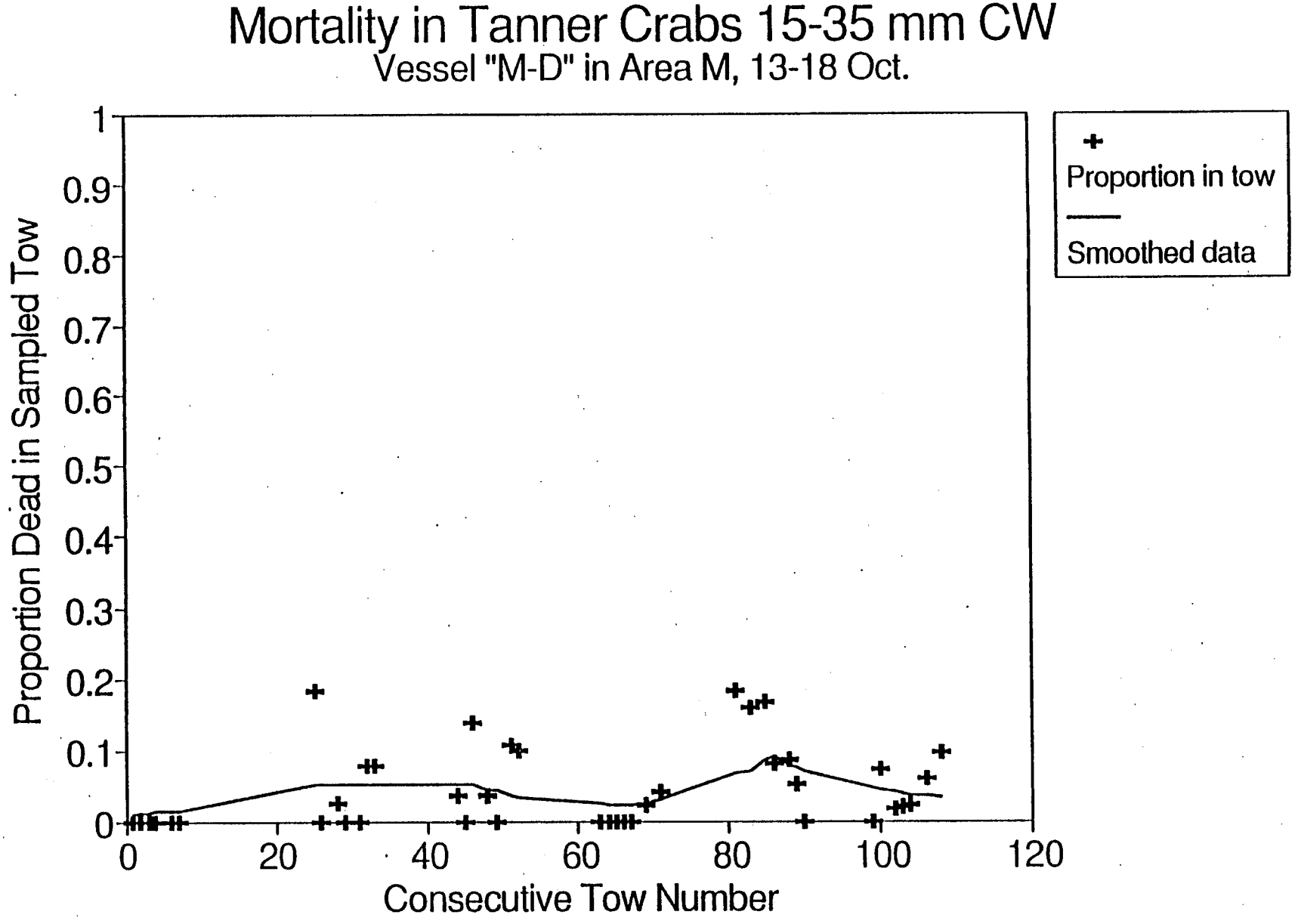
Appendix H.6. Observed mortality rate for sampled Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-A", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.



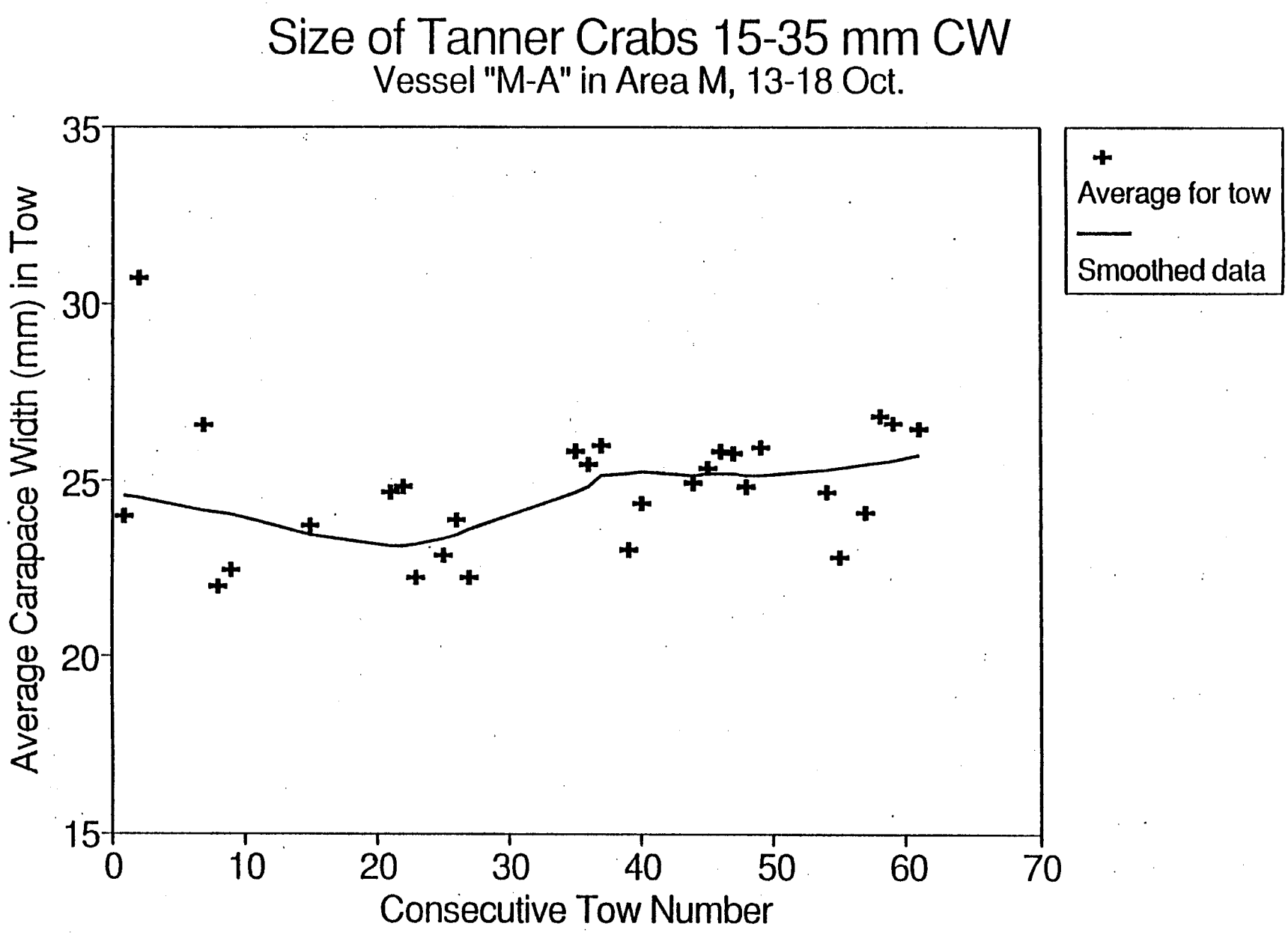
Appendix H.7. Observed mortality rate for sampled Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-B", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.



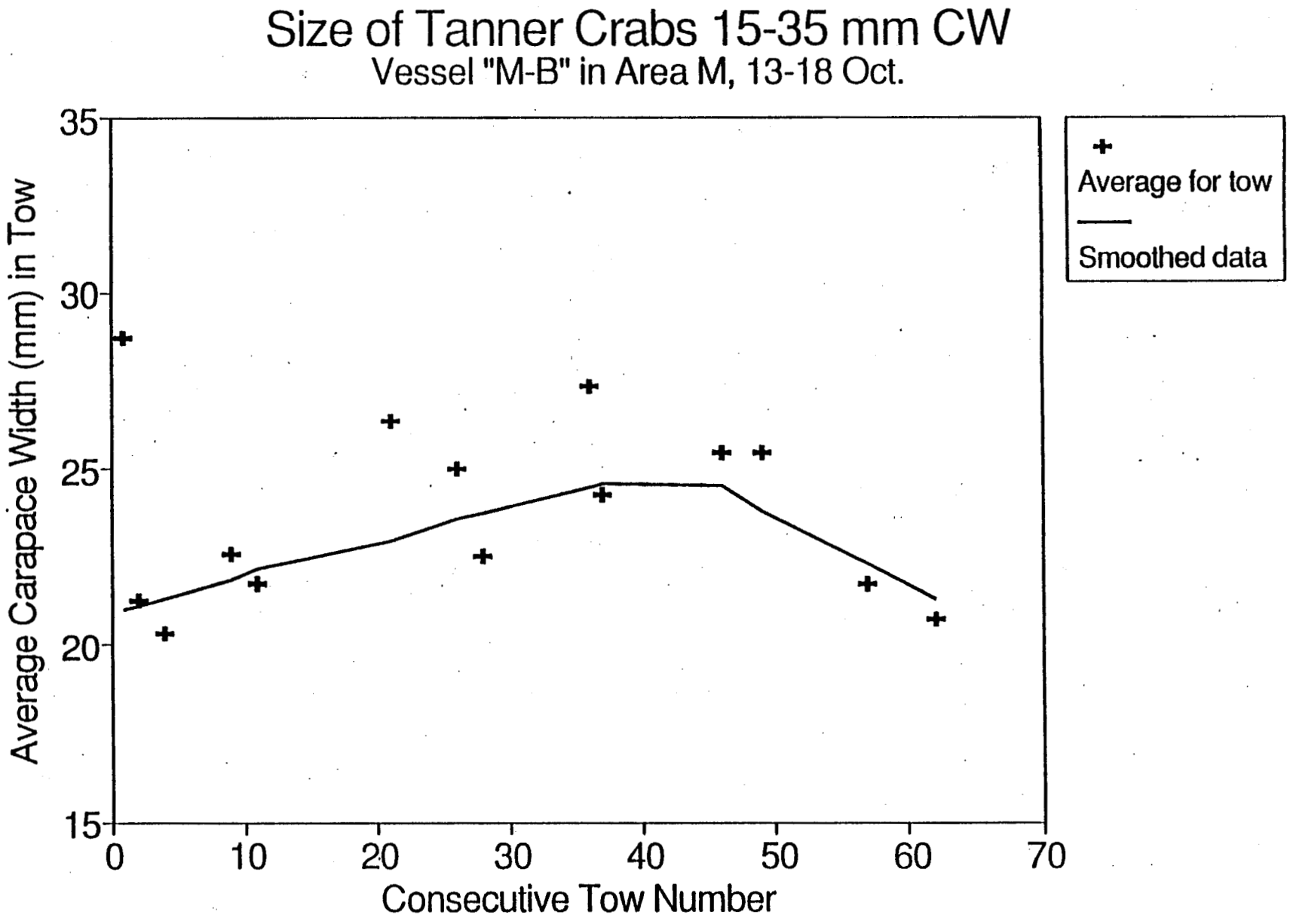
Appendix H. 8. Observed mortality rate for sampled Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-C", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.



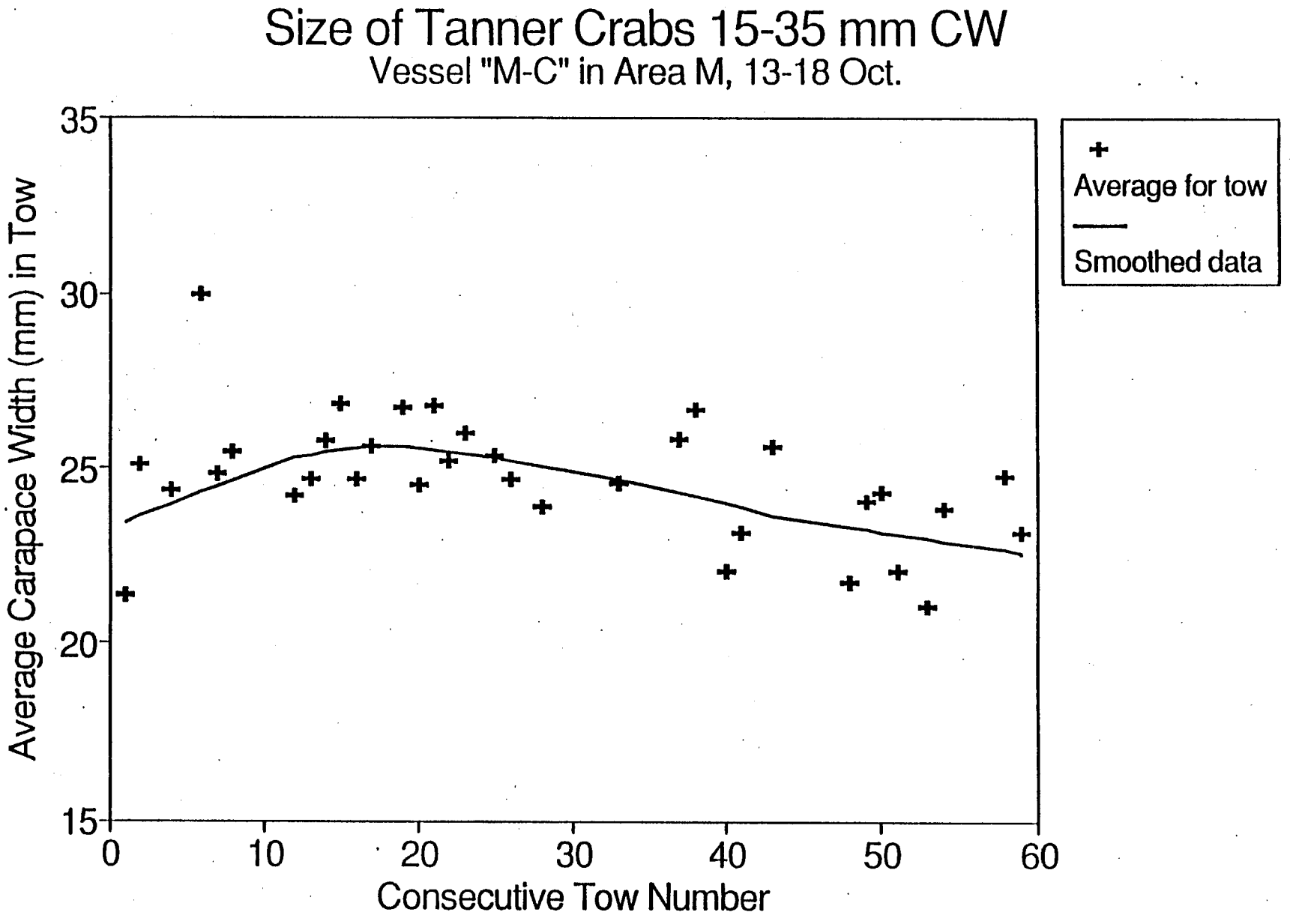
Appendix H.9. Observed mortality rate for sampled Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-D", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.



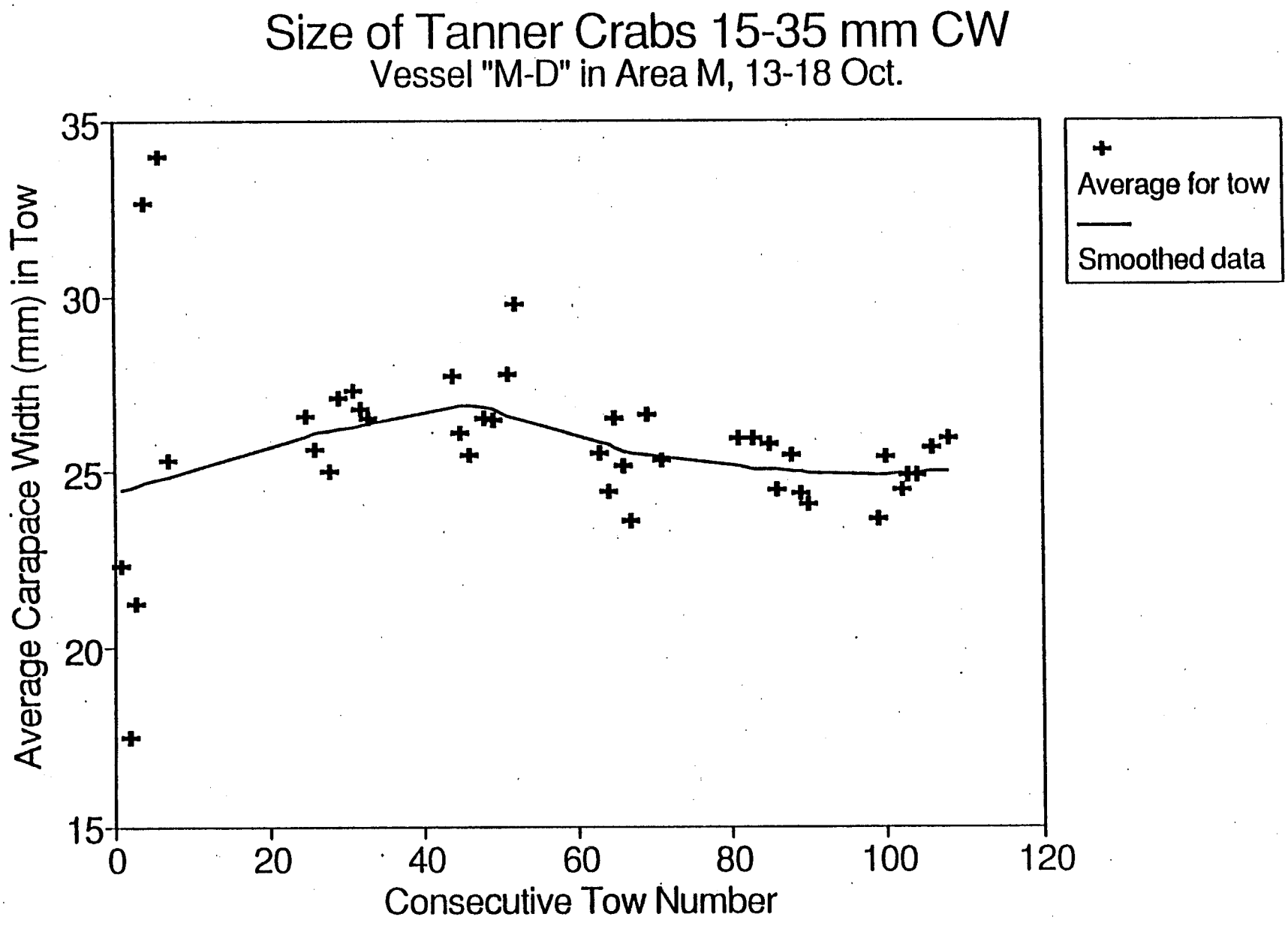
Appendix H.10. Average cw for sampled Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-A", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.



Appendix H.11. Average cw for sampled Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-B", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.



Appendix H.12. Average cw for sampled Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-C", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.



Appendix H.13. Average cw for sampled Tanner crabs in the 15-35 mm cw size class by consecutive tow number for vessel "M-D", Area M, October 13-18, 1993. Solid curve is a local regression smoothing of the data.